SCIENCE

2 October 1959

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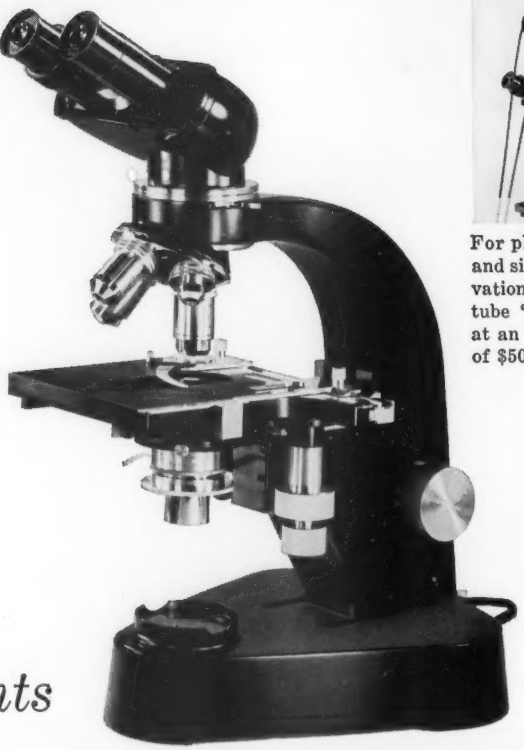

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2 October 1959, Volume 130, Number 3379

SCIENCE

Cover Electron micrograph of a fractured quartz crystal, taken as part of a basic study of fracture surfaces being made at the National Bureau of Standards. Fracture surfaces are of considerable interest in determining the mode of energy dissipation once fracture has been initiated. The crystal was fractured in tension parallel to the basal planes. Replicas were made by the collodion-carbon double-replica technique, with palladium shadowing. The picture shows "steps" meeting at an angle which suggests the presence of a boundary between twin domains. Fracture markings, similar to those occurring in many materials, appear along with cleavage planes, which are of particular interest in view of the extremely poor cleavage of quartz. Such planes are less prominent in fractures propagated along other crystallographic directions. (14,700) [National Bureau of Standards]

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by Norman V. Petersen

Chief of the Astro Systems and Research Laboratories, Norair Division of Northrop Corporation

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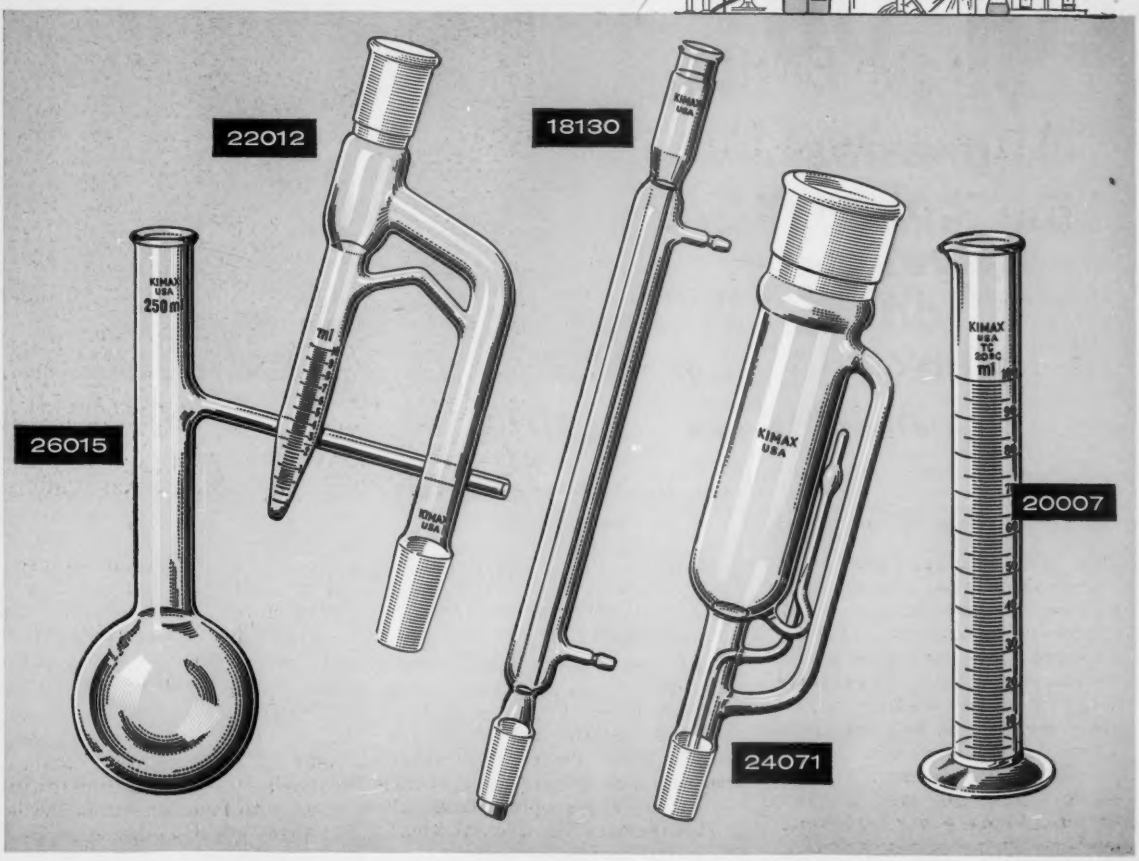

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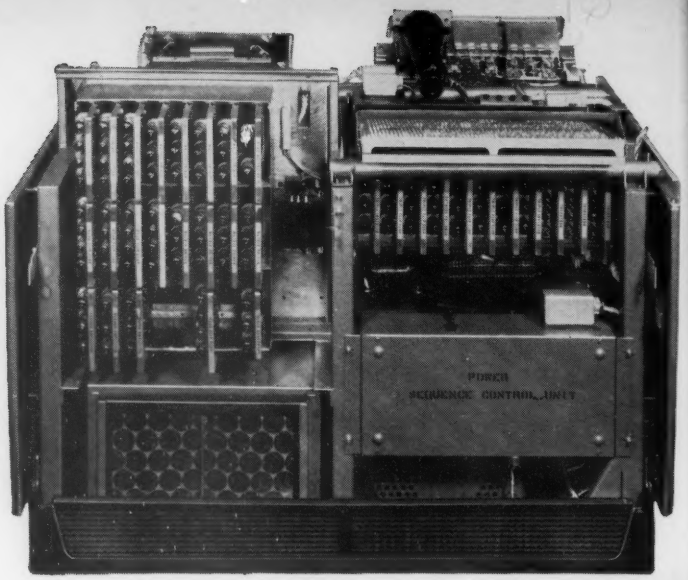

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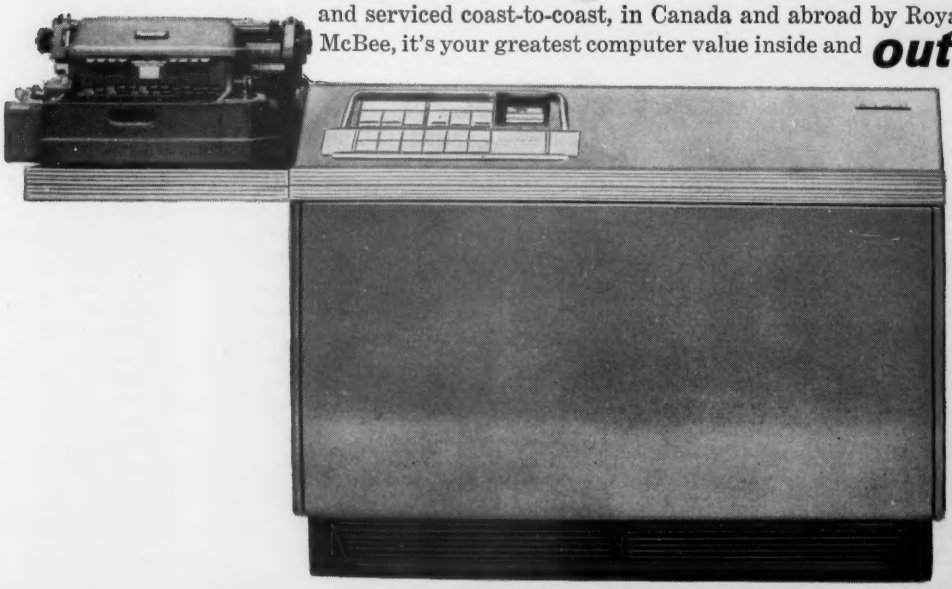

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Letters

Comfort and Environment

Your "Dog days" editorial [*Science* **130**, 131 (1959)] indicates adverse reaction to the "discomfort index" for business reasons. There are additional grounds for dispensing with the new discomfort index. Since human comfort is a rather complex function of ambient temperature, humidity, wind, and radiation load (principally solar, but also infrared as represented by wall temperature in a room), it would appear that a discomfort (or comfort) index should include the effects of all four environmental quantities. Additionally, however, the large individual differences in personal reaction to the physical environment, with both physiological and psychological factors, would appear to make determination of a rational discomfort index a virtual impossibility.

KENNETH H. JEHN

Electrical Engineering Research Laboratory, University of Texas, Austin

Properdin

Having read with great interest D. W. Talmage's "Immunological specificity" [*Science*, **129**, 1643 (1959)], I would like to comment on the hypothesis raised, in reference to the properdin system.

No really satisfactory definition of properdin is available at the present. Although most investigators consider it a discrete entity—"a naturally immune factor"—recent work, especially that of Nelson (*1*), attempts to erase the distinction between the properdin and the classical antibody system. Properdin is considered a "natural antibody of broad if weak spectrum of activity." Although properdin does seem to possess certain distinct physicochemical characteristics, yet discrepancies are found in its immunological activity. For instance, there is lack of correlation of its activity as measured by phage neutralization, zymosan titration, or antimicrobial activity (*2*).

H. Isliker of Bern, Switzerland, indicated recently that properdin is a polymer of 7-S globulins linked reversibly by disulfide bonds (*3*). Thus it may be that the wide spectrum of properdin activity is due to the different affinities of component "natural globulins," and that the lack of correlation in measurements of its activity made by different methods results from variation in the ratios of immunologically different globulins incorporated into the macromolecule.

I have always been impressed by the fact that properdin titers are consistently found to be decreased in infections and malignancies and in military personnel subjected to a massive immunization program (*4*)—all conditions involving a specific antibody formation. As this had never been adequately explained, we felt that something in the nature of a "competitive equilibrium" was involved—properdin polymer dissociating into its component globulins which were then "retooled" to fit the antigens flooding the organism. With Talmage's hypothesis, such a "retooling" would not be deemed necessary, with natural globulins reaggregating into specific complementary patterns. This hypothesis should certainly be easy enough to check experimentally with labeled globulins.

I certainly agree with Talmage that it would be of interest to check whether properdin could be inhibited by the mechanisms of immune tolerance. Zymosan would seem to be the logical inhibitory agent. Such an experiment would be helpful in elucidating the true nature of properdin. A finding of complete suppression would tend perhaps to strengthen the position of those who consider it a natural antibody. Also, it would provide an opportunity to ascertain properdin's role as a defense mechanism.

MICHAEL W. RYTEL

Wistar Institute, Philadelphia, Pennsylvania

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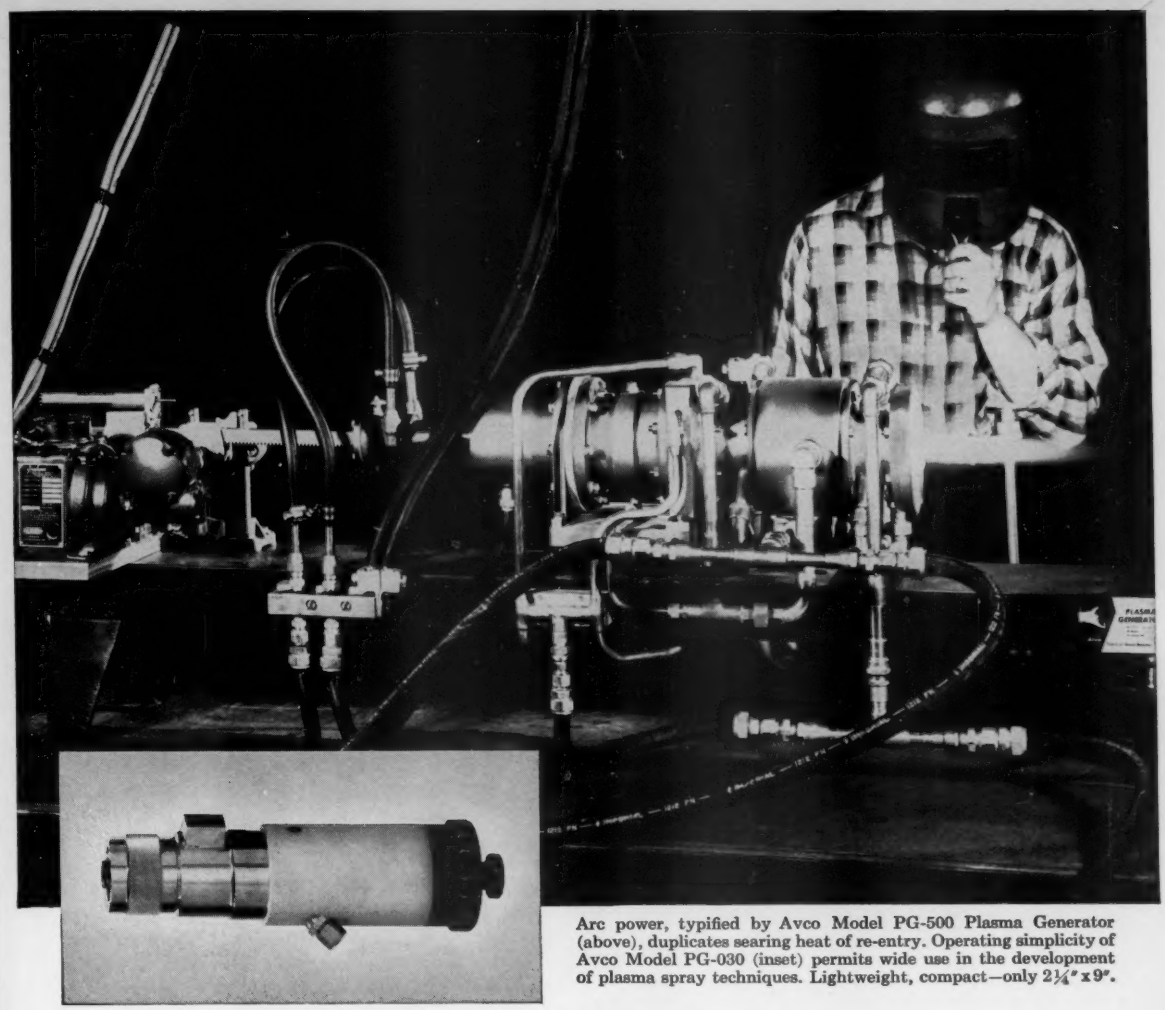
2. K. M. Cowan, *Science* **128**, 778 (1958).
3. H. Isliker, *Proc. Intern. Congr. Biochem., 10th Congr., Vienna* (1958).
4. I. Schultz and G. H. Stollerman, *Clin. Research Proc.* **5**, 304 (1957).

Without commenting directly on Rytel's interesting hypothesis of the nature of properdin, I would like to clarify an apparent misunderstanding of the word *combination* as used in my article. I used the word in its abstract mathematical sense to indicate the number of different ways that independently reactive globulin molecules can be grouped. There was certainly no intention of implying a physical aggregation of natural globulin molecules. Studies with sulfur-35 amino acid incorporation in a number of laboratories have clearly shown that antibodies are formed directly from amino acids *de novo*—that is, not from preexisting globulin or other protein precursors.

DAVID W. TALMAGE

University of Colorado Medical Center, Denver



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2 October 1959, Volume 130, Number 3379

SCIENCE

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Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts and illustrations, see *Science* **125,** 16 (4 Jan. 1957).

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New Garb

From the time when the contents of *The Scientific Monthly* and those of *Science* were combined in January 1958, the number of pages of both text and advertising has gradually increased. The first of these increases is a consequence of deliberate policy on our part: we thought it both desirable and obligatory to expand the text of the combined magazine to approximate the total that had previously been printed in both.

The second increase, that in advertising, is attributable in part to the sharp rise in circulation that was an automatic consequence of the combination of the circulations of the two magazines: circulation of *Science* jumped from less than 40,000 to nearly 60,000. It has now passed the 62,000 mark.

The increase in size of individual copies (the 48-page issue typical of 1957 has given way to the 64-page issue typical of today) and the greatly increased press run have nearly doubled the size of our printing job. The demands of both economy and speed could be satisfied only by the use of larger and faster printing equipment. Consequently, we were reluctantly forced to shift our printing from Business Press, Lancaster, Pa., to the National Publishing Company, Washington, D.C. It was no easy or happy decision for us to terminate our cordial and effective relationship with the Business Press, a press that has performed with consistent high standards of presswork, prompt attention to our needs, and notable devotion to the job of getting *Science* out on time, despite power failures, blizzards, and other hazards.

The shift in printers gave us an opportunity to make a fresh appraisal of the magazine and to consider what changes would be desirable in the reader's interest. We decided to continue to use the same format, which we think is a good one, but to make changes in headings and type faces that would increase readability and help the reader locate material of interest. Thus the general appearance of the pages remains the same, but the type faces are different and, we hope, more readable.

The most immediately obvious change is in the cover. Formerly we used a self-cover (a cover of the same paper stock as the rest of the magazine), but as the magazine increased in weight this became progressively less satisfactory. The separate cover of heavier stock has several advantages: it will permit us to mail *Science* unwrapped and unfolded, and it will permit us to carry cover pictures of subjects of scientific interest. Some of these we will draw from articles that we are publishing, but the great majority will have to come from other sources. We invite our readers' cooperation in supplying us with suitable pictures.

The new cover has one disadvantage: it no longer carries the list of contents, a feature of the former cover that was appreciated by many subscribers. To make the best compromise possible, we have transferred the former cover material in essentially unchanged form to the third inside page. In subsequent issues it will occupy the same position.

So much for the changes. We feel somewhat like an elderly lady (after all, we were born in 1883) who has ventured to appear in a somewhat more daring gown than has been her custom. Like such a lady we hope our new garb meets with favor; unlike her we won't mind sharp and constructive criticism.—G.DuS.

2 October 1959, Volume 130, Number 3379 SCIENCE

CURRENT PROBLEMS IN RESEARCH

The Villafranchian and Human Origins

Man's bipedalism and the use of tools appeared during times of faunal change in the early Pleistocene.

F. Clark Howell

Few people lack curiosity about their ancestors, their genealogy, and the ways of the world in the past. This curiosity extends to the ancestry and history of all mankind. In the last hundred years theological explanations have—especially in countries of Western cultural tradition—tended to be replaced by a more rational approach to the matter. This approach is the concern of human paleontology, and its inception is closely linked with the name of Darwin.

A century ago only a few early human skeletal remains were known, and these only from Western Europe. These represented either the approximately 35,000-year-old Cromagnon people or the (then scarcely recognized) 50,000-year-old "classic" Neanderthal folk. Much understanding of the course of human evolution has been gained since Darwin's time, and especially within the past quarter century (*1*). There are still some extraordinary gaps in the fossil record of the family Hominidae with respect both to specific ranges of Pleistocene time and particular geographic areas. Some such gaps, like the middle Pleistocene range in Mediterranean Africa, have become known only in the last decade, as investigations have been vigorously pursued in the field. However, fossil hominid specimens are still almost entirely unknown from this range of time in Western Asia and in sub-Saharan Africa. The most striking hiatus, particularly since stone artifacts are far from uncommon, is the complete absence of hominid skeletal remains from the Pleistocene in the Indian subcontinent.

In spite of these deficiencies in knowledge, a good deal is known of the major evolutionary stages in hominid phylogeny for the latter half of the Pleistocene. Several distinct, largely geographically restricted lineages are recognized to have existed during the middle, and to have persisted into the early upper, Pleistocene; these probably represented paleospecies (*2*), although some workers consider them to have been generically distinct (*3*). From a portion of one such (*not* Asian) lineage, anatomically modern man (*Homo sapiens*) evolved, but the details of this transformation are still largely obscure (*4*). This best documented aspect of human paleontological knowledge encompasses only the later phases of man's evolution. It is well known largely because of its recency and because there are apparently more abundant traces of human occupation in datable Pleistocene contexts, especially since these can often be linked with effects of the extensive continental glaciations of the Northern Hemisphere. This record thus begins, broadly, during the time of the first of these great continental ice sheets, variously named in Germany (*5*), Britain (*6*), Poland (*7*), and European Russia (*8*).

The main lines of hominid evolution were set during an earlier segment of the Pleistocene. The mammalian faunas of that time range, in Europe, Asia, and Africa, reveal the first appearance of new and modern genera in an otherwise often archaic assemblage. This was an extended period of fluctuating, but generally cooler and more temperate, climates compared with the late Tertiary (Pliocene), leading to mountain glaciation and changing biotopes and biotas. It was a time marked by extensive mountain building, faulting, and upwarping to the extent of several thousand meters, as seen in the Alps, Pyrenees, Caucasus, Atlas, and Himalayan ranges (*9*). This long interval, representing the lower Pleistocene and often termed the Villafranchian after its characteristic fauna, encompasses a time probably as long as the whole of the middle and upper Pleistocene. Half a million years is perhaps a modest estimate. The recent work by Emiliani (*10*), who employed oxygen isotopes in the analysis of climatic change from ocean-bottom cores, gives some promise of providing an "absolute chronology" for the Pleistocene. However, the published climatic curves appear to encompass only the latter half of the Pleistocene—that is, the three major continental glaciations and the intervening Great and Last interglacial stages, the stratigraphy of which closely parallels the core profiles.

The lower Pleistocene represents perhaps the most crucial period for future research in human paleontology. Such efforts promise results of great significance to the understanding of formative phases of hominid phylogeny and the elucidation of those distinctive associated patterns of behavior which differentiated the first hominids from other higher primate (pongid) antecedents and collaterals. I have attempted in this article to indicate a part of what is known of the Villafranchian stage from traces of hominids of this period.

The author is associate professor of anthropology, University of Chicago, Chicago, Ill.

Villafranchian: Europe and Asia

The base of the Pleistocene is best defined by three lines of evidence: tectonics, climatic deterioration, and the appearance and distribution of new forms of animal life. In the majority of stratigraphic sections, an unconformity, representing an interval of uplift and erosion, separates terminal Pliocene deposits from overlying marine or continental (Villafranchian) sediments of the basal Pleistocene. The first signs of marked cooling are evident in the appearance of north temperate or arctic forms (such as *Cyprina islandica* in Mediterranean waters) in marine invertebrate faunas, and in vegetation changes demonstrated by palynology or by the particular conditions of sedimentation. Continental deposits of basal Pleistocene age contain mammalian assemblages referred to as Villafranchian, from the type locality of Villafranca d'Asti in the upper Po river drainage basin (*11*). Such faunas are characterized by the first appearance of the modern genera *Elephas* (*Archidiskodon*), *Bos* (*Leptobos*) and *Equus* (and, in some areas, *Camelus*), but in association with a number of other typically late Tertiary species (*12*). The term *Villafranchian* has also often been extended to apply to this basal Pleistocene interval as well as to the fauna. The termination of the interval is ill defined; it is probably best taken as the base of the Cromerian "interglacial" stage (*13*) or its marine equivalent in the Mediterranean basin, the Sicilian (*14*). This stage immediately precedes the first major continental glaciation.

In western and southwestern Europe (*15*), evidences of fluctuating sea levels, both transgressive and regressive, and of variably cooler climates, unlike the preceding Pliocene (*16*), are recognized at a number of localities. The tilted deep-water Plaisancian and brackish Astian sediments of the (later) Pliocene sea, which flooded many areas of lowland southern Europe which are continental at present, are unconformably overlain in a number of regions (in southern France and Italy) by the marine deposits of the basal Pleistocene Calabrian sea (*17*). The Calabrian, a transgressive sea which was subsequently regressive [compare the Po valley; also the Emilian stage of *Emilia* (*18*)], has as its continental equivalent, developed in unsubmerged and emergent uplands, a series of fluviolacustrine sands and gravels with a markedly cool temperate flora and a characteristic Villafranchian mammal fauna. The contrast with the subtropical vegetation and archaic mammal faunas of the Pliocene is striking and clearly delineated.

The comparable successions afforded by the North Sea basin, in East Anglia (*19*) and the Netherlands (*20*), and by the polliniferous clays and lignites of the lacustrine basin of Leffe (Bergamo, Tuscany) (*21*) illustrate the main pattern of climatic change during the Villafranchian in western and southern Europe (Fig. 1). The evidence would seem to indicate at least two major colder stages, the latter double, prior to the well-defined Cromerian interglacial stage. These two colder stages are separated by the still inadequately known Tiglian "interglacial" stage (*22*). This sequence is paralleled in the Rome region by the Acquatraversan and Cassian phases of colder climate which precede the transgressive Sicilian sea and the extensive eruptions of the Sabatino volcanoes (*23*). A very considerable body of evidence indicates several phases of fairly extensive mountain glaciation during this interval, very probably including the Donau (*24*) and Günz stages in the northern Alps. The

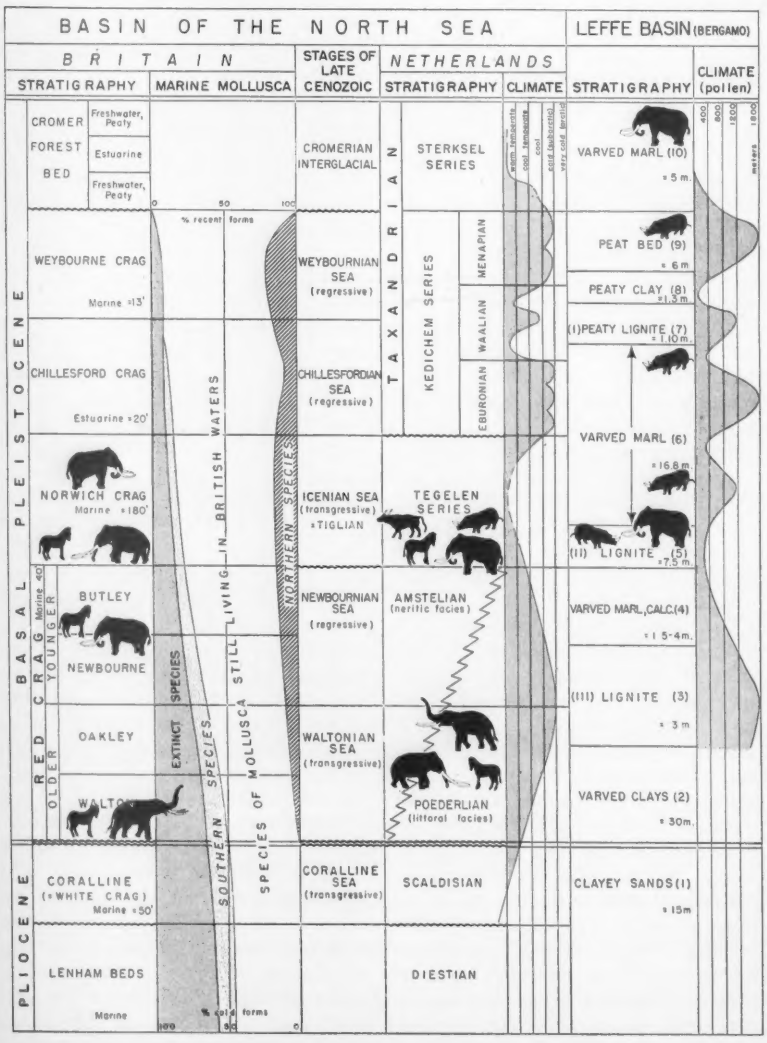

Fig. 1. Villafranchian stratigraphy and climatic change in the North Sea basin and the Leffe lake basin (Tuscany). The silhouettes indicate some of the characteristic species in particular faunal assemblages. The Leffe climate curve, based on palynological evidence, is expressed in terms of present altitude corresponding to vegetation; Leffe is 400 meters above sea level. [Compiled from various sources; see text citations]

first Himalayan glaciation is perhaps the Asian equivalent. However, there is a dearth of evidence of direct correlation of these subalpine stages either with continental Villafranchian deposits in the lowlands or with equivalent marine horizons.

The European Villafranchian lacks any trace of higher primates, and there are no stone implements testifying to occupation of the continent by hominids (*25*). This was probably a consequence of two factors: (i) Europe was not a primary center in the original hominid radiation, and (ii) the extent of the Mediterranean and Black seas (*26*), not only in the Pliocene but also during the Calabrian and Sicilian transgressions of the early Pleistocene, created impassable water gaps which effectively isolated Europe. The first evidence of hominid occupation of the European continent is well along in the earlier middle Pleistocene. It corresponds to the time of the Romanian regression (*27*) of the Mediterranean, when eustatic lowering of sea level attendant upon the first major continental glaciation evidently permitted expansion into Europe of those peoples [probably represented only by the Mauer (Heidelberg) mandible] responsible for the Abbevillian hand-axe industry (*28*).

In eastern Asia the continental Villafranchian is best known in northern China and in the southern foothills of the Himalayas (*29*). In northern China (*30*), the Pliocene, a period of dry subtropical-to-tropical climate with extensive lakes between stretches of desertic country, was terminated by diastrophic movements resulting in extensive erosion (Fenho erosion interval). These formerly widespread lakes were consequently displaced, and rejuvenated rivers and streams greatly enhanced their fluviatile activities. In the synclinal basins of Nihowan (Hopei), Taiku, and Yûshe (Shansi), to mention only the best known, this erosion surface underlies a torrential lacustrine series of basal conglomerates overlain by sands, marls, and clays (lower Sanmenian series); the clays include a plant bed with cool dry flora (Taiku basin), and the series is capped with sands and silts which yield a characteristic Asiatic Villafranchian fauna (*31*). The entire series was tilted and is separated unconformably (by the Huangshui erosion interval) from the early middle Pleistocene red loams (upper Sanmenian series). No evidence of hominid fossils or of tool-making activities have been recorded from the earlier, Villafranchian, beds. The first evidence of hominid occupation is revealed at locality 13, Choukoutien, correlative with the upper Sanmenian series on faunal grounds, which has yielded a single small chert chopping tool but no human skeletal remains.

The entire Pliocene and lower Pleistocene succession is magnificently represented in sub-Himalayan northwest India, both in the Potwar region (Punjab) to the northwest and the Siwalik Hills to the east (*32, 33*). The Pliocene, exposed in the middle Siwaliks series, is represented by fresh-water sandstones and shales, 6500 to 10,000 feet in thickness, deposited under tropical to subtropical climates trending toward increased aridity. The entire series was tilted during a major phase of mountain building followed by an interval of severe erosion at the end of the Pliocene. These movements, either through the development of anticlines or as a result of faulting, created a series of depressions trending northeast-southwest which were filled during the lower Pleistocene with great thicknesses of alluvial sediments (upper Siwaliks series) derived from the adjacent uplands. The earlier Tatrot zone of this series is characterized by a thick (100-foot) basal conglomerate overlain by nearly a thousand feet of coarse sandstone; interspersed silty or conglomeratic horizons contain a (still inadequately known) fauna which is characteristically Villafranchian (*34, 35*). The overlying Pinjor zone, some 1000 to 1500 feet of laminated silts and sands, clearly distinguished lithologically from the Tatrot zone, appears to have been deposited under warmer and more temperate conditions by sluggishly meandering streams, in contrast to the great alluvial activity that accompanied the deposition of the preceding Tatrot. A rich Villafranchian fauna is represented in the Pinjor zone (*34, 36*). However, neither the Tatrot nor the Pinjor provide hominid remains, nor is there evidence of stone tools testifying to hominid occupation. Such tools first appear, as the "Pre-Soan" (Punjab flake industry) chopper–chopping-tool assemblage (*33, 37*), in the overlying boulder conglomerate, attributed to the second Himalayan glaciation, of early middle Pleistocene age.

Discussion of the southeast Asia area of the Sunda shelf, an extension of the mainland in middle and later Pleistocene time, is less pertinent here because of the extensive Pliocene submergence. Only isolated mountain peaks were emergent along the southern (Zuider Mountains) and northern (Kendeng Hills) coasts in eastern Java, and some few uplands in the western region (*38*). A Villafranchian fauna is known from fresh-water sandstones and coarse conglomerates at several localities where these overlie Pliocene marine beds (*39*). However, skeletal remains of two distinct hominids (*Meganthropus, Homo modjokertensis*) first appear only in the early middle Pleistocene (*40*). Sundaland, including Sumatra, Java, and Borneo, and much of the present ocean floor had become largely continental by that time as a result of further uplift and marine regression consequent upon continental glaciation in the Northern Hemisphere. There is no evidence to suggest hominid occupation of the Sunda shelf during the Villafranchian stage.

The present evidence would appear to indicate that continental Eurasia was not occupied by hominids during the lower Pleistocene—that is, the Villafranchian stage. The evidence is admittedly and necessarily of a negative nature, and further field investigations, particularly in the sub-Himalayan Siwaliks, are sorely needed. The important fact is that the available evidence does not bear out the opinions of certain earlier workers (*41*) that Asia, or central Asia in particular, was a primary center for hominid (or higher primate) origin and dispersal. Such a conclusion is contradicted not only by our understanding of higher primate relationships, based on comparative anatomical and paleontological studies, but also by biogeographical and paleogeographical conditions. On the other hand, a variety of evidence shows that the Villafranchian stage in Africa was crucial in the earlier phases of hominid evolution.

African Villafranchian

Mediterranean Africa. Several lower Pleistocene localities with Villafranchian faunas are known in northwestern Africa (*42*) (Fig. 2). One of the best stratified localities is Fouarat (near Port Lyautey, Morocco), along the southern border of the Rharb plain. A Villafranchian fauna is present here in coarse sands and sandstones representing a littoral facies of a Calabrian gulf which in places filled depressions in Pliocene marine sediments (*43*). Hominid occu-

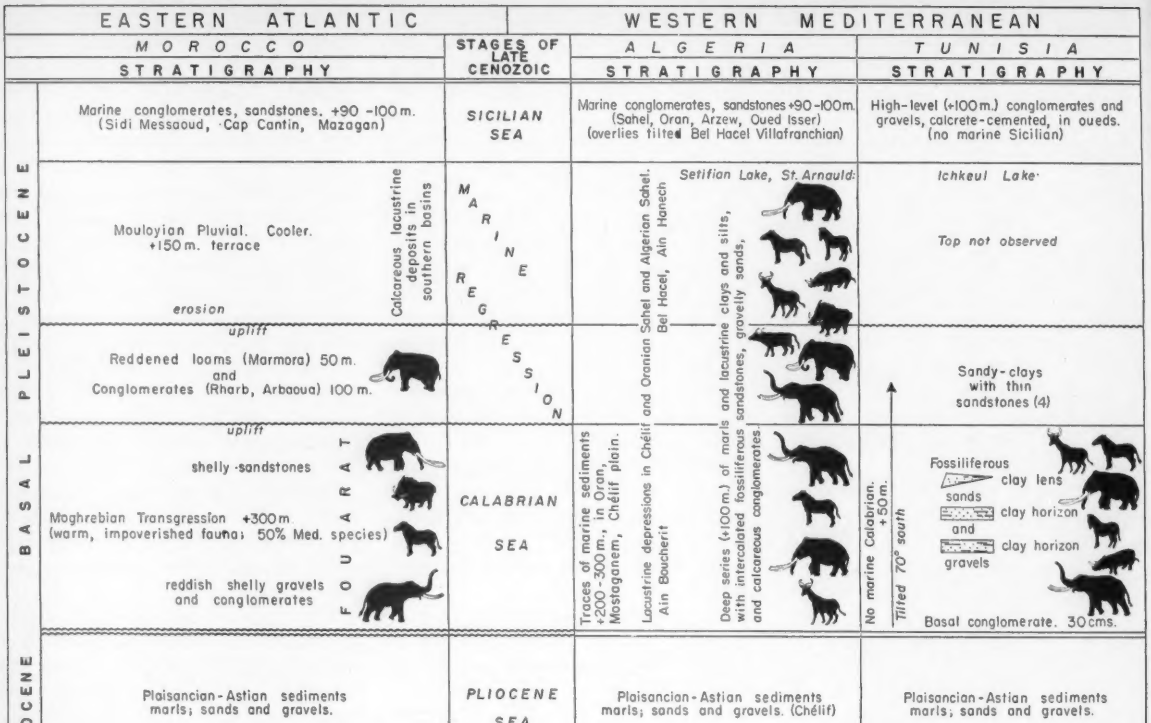

Fig. 2. Villafranchian stratigraphy in northwestern Africa. The silhouettes indicate some of the characteristic species in particular faunal assemblages. [Compiled from various sources; see text citations]

pation of the area is perhaps first recorded at a slightly later stage, probably corresponding to the regressive Emilian. Flaked pebbles, thought by some to represent primitive pebble tools, have been collected from the Arbaoua conglomerates, of basal Pleistocene age (*44*). These deposits, like the reddened Marmora sandy loams, mantle this region and (broadly) represent the continental equivalent of the Calabrian (Maghrebian) transgression (*45*). However, the artificial nature of the specimens is difficult to confirm when they are discovered in this gravel context.

The Villafranchian fauna of North Africa is more adequately known in Tunisia (Garaet Ichkeul), and particularly from old lake basins in northern Algeria (Bel Hacel; St. Arnaud). The base of Lake Ichkeul (near Ferryville) comprises southerly tilted deep-water Plaisancian and lagoonal Astian marine sediments which are overlain by fresh-water lake beds of basal Pleistocene age. The lower sands and gravels of the latter, separated from the Pliocene sediments by a thin conglomerate, are richly fossiliferous (*46*); a mild temperate flora, but with substantial boreal elements, occurs in intercalated, more or less sandy, clays (*47*). However, the full succession at Ichkeul is still poorly known, and the faunal assemblage is incomplete, since the beds are only partially exposed during times of low water, on the northern foreshore of the present lake. At Bel Hacel (*48*) emergent dune sandstones, which concordantly overlie transgressive Plaisancian-Astian sediments, are eroded and filled with alluvial, weathered and reddened, conglomerates which contain terrestrial and fresh-water molluscs and a Villafranchian fauna. The more than 100-meter-high Sicilian beach rests horizontally and unconformably on the tilted and compressed series.

On the Constantine-Setifian plateau near St. Arnaud the earlier Pleistocene is exposed in deep ravines dissecting thick marls and other calcareous clayey sediments, with intercalated gravel and conglomeratic horizons, which fill old marshy or lacustrine depressions. In the Oued Boucherit (*49*), two horizons, separated by a meter of sterile brown clay, contain a Villafranchian mammal fauna. The lower horizon (Ain Boucherit) is a coarse calcareous conglomerate, and the upper horizon (Ain Hanech), a cracked clay, rather sandy or with light gravels at the base. A quantity of undoubtedly primitive stone implements have been recovered here, largely from the upper horizon (*50*). These specimens (Fig. 3) are fashioned from naturally worn dolomitic limestone pebbles, exhibiting fresh, concave flaking scars and ranging in size from that of a tangerine to that of a good-sized orange. They are either battered over most of the surface to a multifaceted polyhedral form (boules) or are flaked along a margin unilaterally or bilaterally to produce an irregular sinuous edge characteristic of choppers or chopping tools. Unfortunately, the Ain Hanech site has been worked only briefly, since both political circumstances and the proximity of a Moslem cemetery have prevented extensive excavations.

No hominid skeletal remains have yet come to light in the formations of the North African Villafranchian. There

is unquestionable evidence of hominid occupation of this region during the terminal phases of the Villafranchian, and a site such as Ain Hanech might one day provide fossilized remains of the creatures themselves.

Sub-Saharan Africa. The central African Pleistocene was initiated by prolonged and extensive uplift, 1000 to 1500 feet at least, accompanied by downwarping in adjacent areas and by fracturing along ancient troughs. Extraordinary volcanic explosions, especially of tuffs and ashes, also took place along the eastern Rift Valley. As a consequence, the mid-Tertiary surface of erosion, whose relief was relatively gentle even during the end-Tertiary phases of valley incision, was severely deformed, and drainage systems were disrupted and even reversed (*51, 52*). Extraordinary depths of lacustrine deposits and subaerial, partially volcanic-derived, sediments were accumulated. These are particularly well preserved in the western (Albertine) and eastern (Gregory) rift valleys and represent good exposures of the continental Villafranchian (Fig. 4).

The Villafranchian, with an overlying middle Pleistocene series (Rawe beds), is also represented along the southern shores of a minor rift valley trending east-west, now Kavirondo Gulf, an eastern embayment of Lake Victoria (*53*). At Kanam, along the north and northeast slopes of the extinct volcano which forms Homa mountain, a great thickness (more than 100 feet) of lacustrine brown clays, with intercalated fine, laminated stony tuffs from intermittent volcanic explosions, have provided a good Villafranchian assemblage. A few pebble tools have also been recovered from such horizons. A small fragment of a hominid mandible is also known (*54*); although it was once believed to date back to the lower Pleistocene, it is now known to be of considerably more recent age.

In the Albertine rift valley an extensive lake existed in the basal Pleistocene, as indicated by the massive (at least 1500 to 2100 feet, to judge from borings) tilted and contorted beds of the Kaiso series (*55*). These are particularly well exposed along the margins of Lake Albert and its southern tributary, the Semliki River, as well as along the northern shores of Lake Edward (*56*) and in the region south of the latter adjacent to the volcanic highlands north of Lake Kivu. The beds seem to attain their maximum exposed thickness in the southerly reaches of Lake Albert and at the adjacent mouth of the Semliki valley; thinner exposures in the upper Semliki and the northern reaches of Lake Edward may merely reflect earlier, more prolonged and intense subsidence of the rift floor in this region.

The Kaiso series is complex, and three main stages of sedimentation have been distinguished (*57*). Only the basal stages are generally regarded as lower Pleistocene; the upper stage is thought to be earlier middle Pleistocene. The lower stage (100 to 120 feet thick in the northern reaches of the valley) is largely silty, with some minor gravel horizons. In some localities this stage is found to overlie a basal ironstone horizon capped by unstratified sands; the ironstone seems to represent a laterite capping the down-faulted peneplain surface and provides an important datum point. This earlier stage is essentially nonfossiliferous. The middle stage (300 to 600 feet thick in the lower reaches of the valley) is predominantly clayey, with selenite evaporites and zones of gypsum. It is characterized by fine sands and sandstones and by discontinuous ironstone horizons and limonite lenses thought to represent desiccated pools. These horizons occasionally provide silicified wood and have yielded a typical, though small (13 species), Villafranchian mammal fauna. Several such ironstone "bone-beds" appear to be present, though they are restricted largely to the middle Kaiso stage (*58*). However, another, perhaps lower, bed is also present in the lower Semliki valley. The site of Kanyatsi (*59*), along the northern shore of Lake Edward just east of the Semliki outflow, has yielded traces of worked stone implements adjacent to an ancient subaerial soil horizon within the middle Kaiso stage. The specimens represent fresh flakes of quartz and quartzite, but the cores from which these were struck are apparently absent, and no pebble choppers or chopping tools have yet been found.

The central region of the Gregory rift valley has failed to provide certain evidence of lower Pleistocene formations; this is perhaps because there was extensive uplift during the later Pleistocene, or because there was relatively little deposition but considerable volcanic activity. The northern and southern reaches of the valley do afford such exposures. The tilted and step-faulted beds of the Omo series, just north and northwest of Lake Rudolph, testify to an ancient and extensive lower Pleistocene lake. A rich Villafranchian fauna occurs in extraordinary profusion in sandstone horizons intercalated in a massive succession of lacustrine vol-

Fig. 3. Pre-Chelles-Acheul implements from the site of Ain Hanech (Algeria). (× ½) [Courtesy C. Arambourg]

canic clayey tuffs (*60*). Neither hominid skeletal remains nor primitive stone implements have been recovered from the Omo series, which, since their discovery by the Bourg de Bozas expedition in 1902-1903, have only been worked during one relatively brief field season. Further investigations in this most inaccessible region are surely warranted, especially since this year I recovered Pre-Chelles-Acheul artifacts from the eroded sandstones.

In the southern reaches of this rift valley the lower Pleistocene is exposed along the tributary Eyasi trough and the adjacent region to the west of the Crater Highlands. At Olduvai Gorge (*61*), which extends from Lake Lagarja on the Serengeti plains some thirty-five miles to the western boundary faults of the Balbal depression, the magnificent lacustrine series of the middle Pleistocene is underlain by a flow of olivine basalt, which buries or obscures earlier horizons. Slightly to the south, in the Vogel river region on the northwest escarpment high above the Eyasi graben, are the Laetolil beds, a series of upfaulted subaerially deposited tuffs (*62*). These appear to be earlier than, as well as in part contemporaneous with, the Olduvai series. The upper Laetolil beds have yielded a rich Villafranchian assemblage of mammals, including some microfauna (*63*). The lowest horizons are also fossiliferous, but the fauna is very poorly known. Pebble tools and a hominid maxilla fragment (*64*), the latter believed to resemble the australopithecine (*Australopithecus*) (*65*), attributed to these beds may in fact be of later Pleistocene age. The basal bed (Bed I) at Olduvai Gorge is now known to contain a Villafranchian faunal assemblage comparable to that from Omo rather than of middle Pleistocene affinity. Pre-Chelles-Acheul stone implements of the Oldowan industry were first found here nearly 30 years ago. In July Dr. and Mrs. L. S. B. Leakey recovered a beautifully preserved skull of a new form of australopithecine from this bed in association with an occupation surface rich in such artifacts and with the bones of small game taken by this creature (announced at the 4th Pan-African Congress on Prehistory, Leopoldville, August 1959).

Central and eastern Africa afford some of the richest Villafranchian faunal localities in the world, coupled with an excellent Pleistocene succession. The faunas from these sites differ somewhat in composition, that from the Laetolil beds being probably the youngest, overlapping basal Olduvai, and that from Kaiso being perhaps the oldest. The Omo fauna overlaps both Laetolil and Kaiso, and that from Kanam is probably broadly equivalent (*52, 66*). As yet it is impossible to determine the magnitude of the climatic change that occurred during the Villafranchian of central Africa because of the effects of tectonics in this unstable region. At present only a broad block correlation with other areas of the Old World, on the basis of faunal content, can be made. Future detailed investigations of the sediments in these basins, particularly of nonsequences and old soil horizons, coupled with palynological research, promise to throw some light on this problem.

At three such localities, Kanyatsi (Lake Edward), Kanam (Kavirondo, Kenya), and Olduvai Gorge, there is clear evidence of hominids, sometimes in the form of skeletal remains and, in all cases, in the form of deliberately fashioned stone tools. Few open habitation sites of the hominids themselves have yet come to light; however, this is largely a result of too little field work in difficult regions. There is every indication that such sites will be forthcoming in the future with concentrated work by prehistorians and Pleistocene geologists. Very complete evidence of such early hominid forms, including abundant skeletal remains, is afforded by the australopithecines of southern Africa (*67*).

Australopithecine Sites

The australopithecines now rank among the most numerous and best known of all Pleistocene hominids. Usually classified as a distinctive subfamily (Australopithecinae) (*68*) of the Hominidae, but quite probably representing merely a distinct genus, *Australopithecus* (*69*), the group contains two probably subgenerically distinct forms, (*Australopithecus*) and (*Paranthropus*). On the basis of the associated faunal assemblages, it appears that the australopithecines are all probably late Villafranchian (*70*); however, there is a possibility that the younger form (*Paranthropus*) may have persisted into the early middle Pleistocene (*71*).

Australopithecines are known from five sites at three localities (Fig. 5) in southern Africa (*72*). With one exception (Taungs) they occur in fossiliferous breccia, composed of calcite-cemented dolomite soil, which infills former caves, formed by solution or subsidence along ancient fracture planes in dolomitic limestones of the Transvaal system. Studies of the mode of formation and the sequence of infillings of these caverns has demonstrated the significance of the degree of communication of the cavern with the outside in the accumulation of sediments (*73*). Travertines and intercalated bands of thin gray marly breccia, representing residual calcified material from dissolution of the dolomite, accumulate prior to the formation of any substantial opening to the surface. Subsequently, as the opening becomes progressively enlarged, surface-derived material collects in sufficient quantity to represent a state of equilibrium with outside conditions. Such breccia accumulations may serve as climatic indicators, through analysis of the sand fractions of breccia residues, minus the carbonate cement derived from roof drip, and comparison with modern dolomite soils in regions of differing rainfall in southern Africa. Very satisfactory results have been thus achieved for the Sterkfontein, Swartkrans, and Kromdraai (site A) sites; the method is not directly applicable to the Limeworks Cave site, Makapansgat, where alluviation or slope-wash, in the higher levels, are complicating factors. In general, the climate appears to have been somewhat drier in this region when (*Australopithecus*) lived and somewhat, or even considerably, wetter when (*Paranthropus*) lived than it is now. Brain (*73*) refers the three older Transvaal sites (Sterkfontein, Limeworks, Swartkrans) to a major dry interpluvial stage (with at least three separate peaks) and the youngest site, Kromdraai, to a succeeding, wetter pluvial stage.

The Taungs site, long since destroyed by quarrying activities, was a cave formed by solution in the capping carapace of a massive basal Pleistocene travertine banked up against a dolomite limestone cliff (Campbell Rand series) (*74*). The filling of the cavity was calcified sandy breccia overlain by contaminated travertine with sandy lenses from which the type australopithecine remains were most probably recovered.

The fauna associated with the australopithecines is not only varied but differs from site to site. In general it comprises other primates (both rare monkeys and abundant baboons), nu-

Fig. 4. The Rift Valley system and Villafranchian localities in eastern Africa. [Base map and major faults redrawn from the geological map of East Africa prepared on behalf of the Inter-Territorial Geographical Conference, 1952; stratigraphical inset from H. B. S. Cooke, *52*]

merous rodents, insectivores, hyracoids, lagomorphs, numerous carnivores, including hyaenids and sabretooths, suids, an extinct sivathere, equids, and numerous antelopes. The following frequencies were obtained from counts of over 7000 bone fragments, out of a much larger number, from remnants of the gray marly breccia at Limeworks Cave (*75, 76*): 92 percent, antelope (293 individuals; more than two-thirds medium to small, the remainder large or very small varieties); 4 percent, other ungulates (four zebras, six chalicotheres, five rhinoceroses, one hippopotamus, 20 pigs, six giraffids); 1.6 percent, carnivores (17 hyenas, one leopard, one jackal, one wild dog, one sabretooth, and nine other small and medium species); 1.7 percent, baboons (45 individuals), rare rodents (hares and porcupines), and very rare birds and reptiles (tortoise, water turtle). Five australopithecine individuals represent only 0.26 percent of the total assemblage.

The various segments of the skeleton are very unequally represented at this site. The frequency of cranial fragments is particularly high among the nonbovid ungulates (88 percent), the carnivores (75 percent), the rodents (100 percent), and the primates, including the australopithecines (95 percent). The proportions are lower (34 percent) among the antelopes (of all sizes), and there are interesting differences in frequencies of antelope postcranial elements: cervical vertebrae (7 percent), other vertebrae (5 percent), ribs, and so on (5 percent), scapulae (9 percent), innominates (8 percent), forelimbs (37 percent), hindlimbs (20 percent), feet (6 percent) (these figures do not apply to very small antelopes, which are represented exclusively by cranial elements).

Any consideration of the diet and life habits of the australopithecines must take into account the associated fauna and frequencies of preserved skeletal segments. Hence, such figures are important and are much needed from the other sites. Several possibilities exist as to the manner in which the australopithecines and the associated fauna came to be incorporated into the breccias. The sites might have been (i) natural crevices into which animals fell; (ii) crevices into which bone accumulations were swept by natural agencies; (iii) carnivore lairs into which prey or scavenged carcasses were carried; (iv) rubbish heaps; or (v) actual occupation sites of the australopithecines. There is no evidence at any of the sites to support (i) or (ii), although the gravelly breccia at Limeworks Cave was partly fluviatile in origin; there is also evidence of stratification in the upper brownish breccia at Swartkrans, probably due to deposition in isolated pools but certainly not the consequence of stream activity. It will always be difficult to decide between (iv) and (v), but the important and still unsettled question is whether the sites were occupied and the bones were accumulated by carnivores, in particular sabretooths or hyenas, or both, or by carnivorous australopithecines.

It is necessary to bear in mind that these sites are known because of commercial lime-quarrying activities. In most cases such efforts were directed toward the basal travertines, formed largely when the caves were still solution cavities. In the case of Taungs the cave was discovered as a consequence of such mining in the massive cliff-forming travertines at Buxton, in one of which the cave happened to be situated. All the fossil mammals at the Limeworks Cave, Makapansgat, have been obtained by sorting through the extensive dump heaps left behind by the miners. Only in the case of Swartkrans (*77*) (in part) and some of the excavations at Sterkfontein have investigations been carried out which would permit some comprehension of the fossiliferous breccias as they existed *in situ*. However, the extreme consolidation of the fossil cave earths, a consequence of calcareous cementation, necessitates the use of explosives, so results are definitely limited with respect to details of the pattern of association and the arrangements of bones in the deposits. In the present state of knowledge it is indeed doubtful if the matter can be definitely settled until a new site can be excavated, with every attempt made not to disturb the stratigraphy and fossil associations.

Dart (*75, 78*) has repeatedly maintained that the extraordinary accumulations of mammalian skeletal remains in the fossiliferous breccias are a direct consequence of the predatory and carnivorous habits of australopithecines. Such remains represent in his opinion not only slaughtered prey but also scavenged carnivore kills; many of the bones were useful as tools and weapons for pounding, cleaving, scraping, stabbing, and slicing. On the basis of the preserved remains inventoried at Limeworks Cave, specialized functions have been attributed to specific bones and portions of animal skeletons that were put to use by those "flesh-eating, skull-cracking and bone-breaking, cave-dwelling apes."

There are in fact two distinct issues involved here. The question as to whether the bones were employed as implements and weapons by australopithecines presupposes that these creatures were carnivorous and were therefore responsible for the fossiliferous accumulations. The use of these bones is extremely difficult to verify, since none of the sites yield any trace of specimens which have been deliberately worked or shaped. There is no doubt that the jaws and teeth, horns, and shattered or damaged limb bones which Dart attributes to an "osteodontokeratic culture" might be employed in the fashions he has so exhaustively and imaginatively outlined. However, as in the case of the so-called "bone and antler industry" from the Choukoutien locality in northern China, attributed by Breuil (*79*) to the middle Pleistocene hominid found there, this is extremely difficult to confirm scientifically, even though both claims may prove entirely valid.

The question of the carnivorous habits of australopithecines is a separate matter and one which should be resolved from existing evidence. The parts and proportions of the animal skeletons preserved do coincide closely with remains at carnivore kill sites in the open, even after the usual scavengers have been at work (*80*). Moreover, although contrary claims have been made (*81*), both brown and spotted hyenas may eat and accumulate bones in and about their lairs, at least at times (*82*). Nonetheless, this possibility does not account for the enormous concentration of bones at the sites. Also, there are discrepancies between the proportion of cranial and postcranial elements of the antelopes compared with the other ungulates, the carnivores, and the primates.

Two main points are important in connection with the dietary habits of these creatures: (i) the evidence from Taungs, Sterkfontein, and Limeworks Cave of baboon skulls bearing evident signs of localized depressed or radiating fractures, smashed-in walls or tops of the cranial vault, openings in the vault or base, and twisted facial skeletons all testify to predatory activities which are those of a hominid rather than any

hyaenid or felid carnivore; and (ii) the substantial quantity of various antelope and other long bones which are not only broken and smashed but also split longitudinally, and which usually fail to reveal any traces of carnivore gnawing, is further testimony to hominid habits.

Such evidence has been convincing not only to me, but also to other workers (*83*) who have examined the specimens in question. Moreover, it seems very likely, on the basis of the Taung evidence, that eggs, crabs, turtles, birds, rodents, and smaller antelopes were a not insubstantial part of australopithecine diet. The former such items are easily collected, and it is not particularly difficult to kill members of the other species of smaller mammals. The australopithecines were very probably carnivorous predators as well as scavengers of the kills of other carnivores (of which there was then an abundance of forms long since extinct). The marked disproportion between the bovid and nonbovid ungulates and the relatively few carnivores in the Limeworks Cave inventory may merely be a reflection of this latter fact and of the limited hunting capabilities of such creatures. Such a conclusion does not preclude the possibility that carnivores also, at least periodically, occupied such sites and contributed to the bone accumulations. This can hardly be denied until careful excavations have been carried out which prove the situation to have been otherwise.

Until recently none of the australopithecine sites were known to contain artifacts. Consequently, many workers asserted that such primitive creatures, although admittedly hominids, were incapable of making, and perhaps even of using, tools. Quite possibly this lack of stone implements has also convinced some workers that bone, horn, and teeth of other animals were used by australopithecines as weapons and implements. A few split and flaked dolomite pebbles from the calcified stony and sandy fluviatile horizon which overlies the pink and gray breccias at Limeworks Cave (*84*) suggest but do not afford conclusive proof of tool-making activities. However, there is no doubt about the validity of the implements (Fig. 6), referred to a pebble-tool (Pre-Chelles-Acheul) industry, recovered recently from the Sterkfontein locality (*85*). The specimens derive from a reddish-brown breccia at the extension site first thought to be broadly contemporary with the basal pink australopithecine-bearing breccia of the type site. Robinson's (*86*) more recent investigations indicate, however, that these breccias are separated unconform-

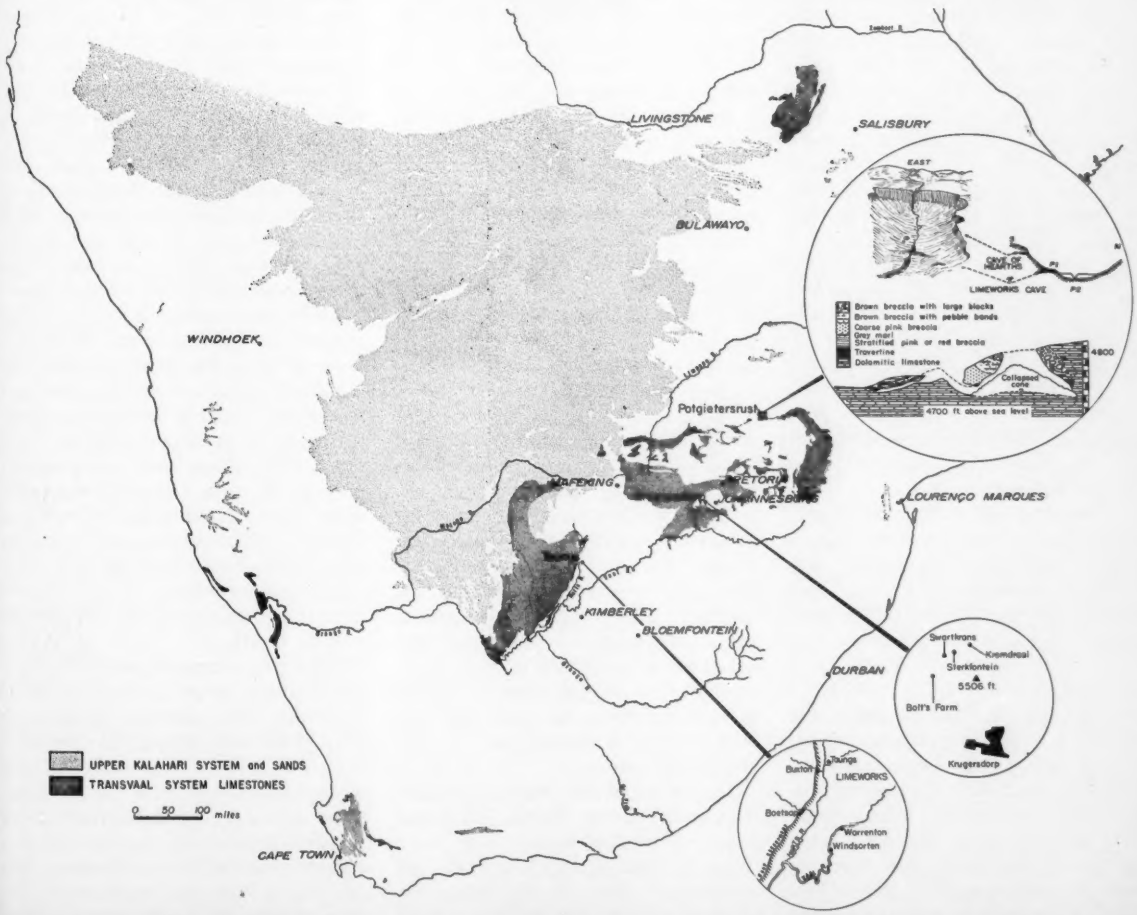

Fig. 5. Australopithecine localities in southern Africa. [Base map redrawn from the geological map of southern Africa in A. L. du Toit, *The Geology of South Africa*, ed. 3, 1954; insets adapted from G. B. Barbour, H. B. S. Cooke, J. T. Robinson, and F. E. Peabody]

ably, as a consequence of subsidence, and that the latter pink breccia underlies the reddish-brown breccia of the extension site. The latter contains the foreign and worked stones as well as some fauna (including *Equus*, absent in the type site basal pink breccia) and some remains (isolated permanent teeth, a juvenile maxilla fragment with several teeth) referred to *Australopithecus*.

The specimens recovered from Sterkfontein include pebble- and core-choppers (8), a chopper-hammerstone (1), and rough retouched end-struck flakes (2). Quartz, quartzite, chert, and diabase pebbles foreign to the deposit were also found; about half (24) of these were plain, and the other half (23) exhibited evidence of fracture from use. The small flakes struck from the choppers and cores are missing and indicate that the specimens were collected and worked elsewhere, near streams where raw material was available, prior to being carried to the site for use. Some of the specimens show extensive battering rather than careful flake removal, suggesting either hard use or, according to J. D. Clark (*87*), poor workmanship. The implements are fresh and unweathered and cannot have been washed in from the outside, since the breccias must have accumulated under an overhanging roof, and since the breccias fail to reveal such conditions of deposition. The artifacts seem to be concentrated at the western end of the site near the original entrance to the cave and were undoubtedly left behind by the hominids who occupied this end of the cavern.

The recovery of pebble tools in association with australopithecines is a momentous discovery. There now seems little doubt that these primitive creatures were already capable of using and manufacturing implements of stone and, presumably, of other nonpreserved materials as well. The extraordinary concentration of other mammalian bones would indicate that these creatures were capable of killing the moderate- and smaller-sized species; probably they also scavenged carnivore kills. There is no indication that they had the ability, the equipment, or the organization necessary for killing very large mammals, in contrast to middle Pleistocene peoples. Such carnivorous habits would have required some sharpened stone implements, such as flakes and chopping tools, for cutting open the hide of kills to obtain meat. There is no trace of the use of fire at this early time.

Clark (*87*) has recently suggested that the availability of water in the cave systems may have been an important factor in their having been occupied. Except for small and seasonally dry streams, cave and fissure systems, and springs related to them, provide the best source of water in such limestone country. Such sources of water would have attracted game and australopithecines alike and would have provided ideal conditions for the latter to prey on antelopes, pigs, baboons, and other animals which came to drink there. This also readily accounts for the profusion of animal bones accumulated in the cave and for the presence of implements necessary to butcher the slaughtered game.

Australopithecine Morphology

Hominids and pongids (apes) are generally regarded as closely related higher primate groups (hominoids). There are obvious and significant morphological and behavioral differences between the living representatives of the two families. Acceptance of the fact of evolution and the reality of such close affinity indicates, however, that such divergences were fewer and less sharply delineated in the remote past. The *primary* adaptation of the hominid radiation required transformation of the locomotor skeleton to permit fully upright posture and an efficient bipedal gait (*88*). This mode of terrestrial locomotion contrasts markedly with the arboreal or terrestrial quadrupedalism of the lower catarrhine monkeys or with the arboreal brachiation of the pongids, coupled, in the larger pongine (anthropoid ape) species, with semipronograde quadrupedalism. This basic locomotor adaptation of the hominids was doubtless preadaptive for subsequent evolutionary changes which affected the skull—reduction of the facial skeleton and extraordinary enlargement of the cerebral hemispheres and cranial vault. The latter has been linked with enhanced cultural capacities, although the manifold interrelationships between structure and function, and their behavioral significance, are still very largely obscure.

The pelves of four australopithecine individuals are now known. Three represent (*Australopithecus*) and were found at Limeworks Cave (*89*) and Sterkfontein (*90*) (at the latter site, much of an associated vertebral column was also found); (*Paranthropus*) is represented by one incomplete innominate bone from Swartkrans (*91*). These fortunate discoveries demonstrate conclusively that the pelvic structure of these creatures was that characteristic of primitive bipedal hominids. They also greatly add to our understanding of the hominid locomotor transformation, which involved a complex of interrelated structural modifications. These constituted a basic reorientation of the pelvis in relation to the trunk, interrelated changes which permitted an erect trunk and full extension of the lower limbs in stable upright posture (and in the female, maintenance of the bony birth canal).

Such changes involve (i) expansion of the iliac blade, especially the auricular area, coupled with sacral rotation and accentuated lumbar lordosis; (ii) shortening and anterior rotation or "twisting" of the ilium, with attendant development of a sigmoid curvature of the iliac crest; (iii) thickening of the outer bony table above the acetabulum (to aid in balance and weight support); (iv) development of an iliac cristal tubercle, in line with the strengthened supra-acetabular region (related to differentiation and expansion of the iliotibial tract as an aid in stabilization of the hip and knee joints in standing and walking erect); (v) enlargement and approximation to the acetabulum of the anterior inferior iliac spine (related to the size of the straight head of the *rectus femoris* muscle, as part of the general enlargement of the *quadriceps femoris* muscle group in bipeds); (vi) shortening of the ischium and altered form of the ischial tuberosity (the full significance of this is obscure, but it is apparently related to the position of the extensor, or hamstring muscle, lever arm); (vii) enlargement and displacement of the *gluteus maximus* muscle as a powerful extensor (rather than a lateral rotator as in apes and monkeys); and (viii) altered function of *gluteus medius* (and *minimus*) muscles as abductors (to maintain lateral stability in walking erect).

There are accompanying interrelated modifications in the proximal head of the femur. These include: (i) enlargement of the femoral head; (ii) development of the lesser trochanter (related to an altered disposition of the *psoas major* muscle); (iii) development of the anterior segment of the greater trochanter and the intertrochanteric line (related to the attachment of the Y-shaped ligament of Bigelow and the joint capsule); (iv) development of the *linea aspera;* (v) shift of *gluteus maxi-*

mus to a posterior rather than a lateral insertion, as in apes, in the place of *adductor minimus* and expansion of *vastus intermedius;* and (vi) notable reduction of the *quadratus femoris* muscle. Other modifications of the distal end of the femur, including the obliquity of the shaft, the marked depth of the patellar surface, the configuration of the intercondylar notch, and the enlargement of the lateral condyle, were apparently associated in large part with enhanced stability of the knee joint in orthograde progression.

The basic morphological pattern characteristic of hominid bipedalism is apparent in the australopithecine lower limb skeleton so far as it is known (*92*). There are a number of minor differences—for example, in the form of the ischial region—from the pelvic morphology of *Homo sapiens*, a not unexpected finding in a primitive lower Pleistocene hominid. The australopithecine lower leg and foot, except for a talus of (*Paranthropus*), is still largely unknown.

The morphological pattern of the australopithecine dentition is also hominid rather than pongid (*93*). In the deciduous dentition this is evident in (i) the evenly curved dental arch, lacking diastemata; (ii) the small milk incisors; (iii) the small, nonprojecting spatulate milk canines; (iv) the quadricuspid upper first milk molar; (v) the nonsectorial, quinticuspid lower first milk molar with well-developed anterior fovea and cusps of approximately equal height. In the permanent dentition this is evident in (i) the evenly curved (parabolic) dental arch; (ii) the small incisors; (iii) the small, nonprojecting spatulate canines, lacking a talonid and with the internal cingulum forming a basal tubercle; (iv) the double-rooted upper first premolar; (v) the nonsectorial, bicuspid lower first premolar; and (vi) the replacement sequence, in which both the permanent canine and medial incisor tend to erupt relatively early.

The related structure of the facial skeleton is also primitively hominid, and this is paralleled in a number of structural details of the cranial base and the occiput. The brain, in proportion to body size, in certain aspects of its form and proportions, and in its tendency toward delayed maturation, approaches a primitive hominid rather than a pongid condition.

There are consistent morphological distinctions between the earlier form (*Australopithecus*) and the younger form (*Paranthropus*) (*94*). These are evident not only in the deciduous and permanent dentitions and the facial skeleton but also in the structure of the cranial base and vault, as well as in the known portions of the postcranial skeleton. (*Australopithecus*) was a small, gracile bipedal creature, weighing certainly no more than 75 to 85 pounds in the larger males. (*Paranthropus*), on the other hand, was a far more robust and massive creature of probably half again that body weight. Such, probably subgeneric, differences indicate a pronounced bifurcation within a primary australopithecine radiation, at least in the basal Villafranchian and possibly even in the later Pliocene. Unfortunately the general absence of fossiliferous Pliocene horizons in sub-Saharan Africa has thwarted investigation of the earlier evolutionary phases

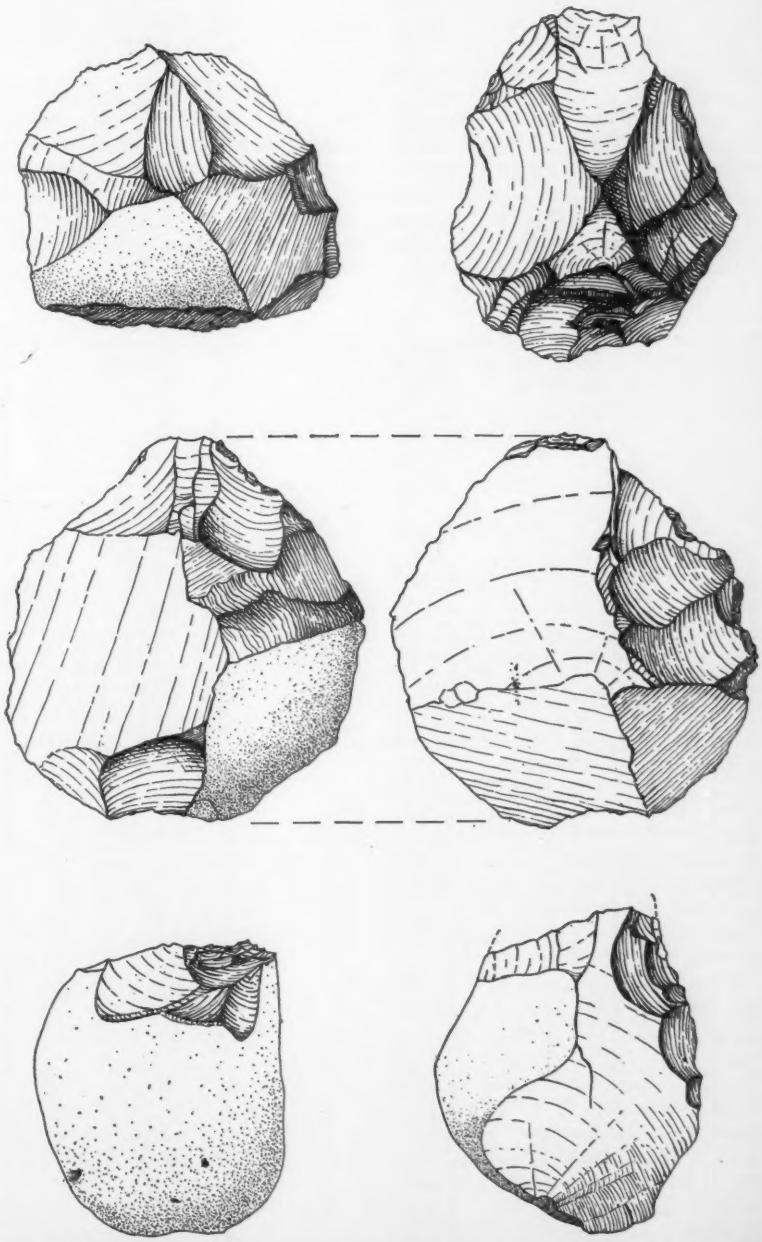

Fig. 6. Pre-Chelles-Acheul implements from the australopithecine-bearing breccias at Sterkfontein (Transvaal). [After J. T. Robinson and R. J. Mason, *85*]

and primitive hominoid antecedents of the australopithecine group.

At Swartkrans another distinct hominid, designated *Telanthropus*, is found in direct association with the australopithecine (*Paranthropus*) (*95*). This form, which is still only very inadequately known, differs markedly from (*Paranthropus*) in dental and mandibular morphology and in certain features of the maxilla (in particular in the structure of the nasal floor). In all such characteristics, some of which reveal some resemblances to the earlier australopithecine (*Australopithecus*), this hominid is further evolved morphologically than any known australopithecine and approaches therefore the phylogenetic status of certain earlier middle Pleistocene forms attributed to the genus *Homo*. The full implications of this conclusion cannot be properly evaluated until additional, more complete specimens have been discovered.

Tertiary Hominoids and Villafranchian Hominids

It is significant that the African Villafranchian hominids differ considerably in morphology from later Tertiary hominoids of eastern Africa and Eurasia. Four hominoid genera are recognized from the earlier Miocene of eastern Africa, three and possibly four genera (*96*) are recognized from the middle and late Miocene and the lower Pliocene of peri-Alpine Europe, and four genera are recognized from the (upper) lower and middle Siwaliks of Asia (Fig. 7).

In both Africa and Europe primitive hylobatids (gibbons) are already evolved in the lower half of the Miocene. Most of the basic cranial and dental morphology of the group is already established in these forms; in fact the dentition is already basically hominoid in the Oligocene form *Propliopithecus*. However, in some features of postcranial structure and in limb proportions these forms differ significantly from their living representatives (*97*). Similarly, the basic dryopithecine (pongid) dental characteristics are manifest in the earlier Miocene hominoids of eastern Africa, although cranial and facial morphology is distinct from that of evidently specialized living varieties of the group (*98*). Moreover, the fundamental locomotor pattern of the recent large-bodied brachiator is evident in the morphology of shoulder and elbow joints, whereas the skeleton of the hand is distinctly primitive cercopithecoid or monkey-like (*99*). The later Miocene and Pliocene dryopithecine hominoids of Europe and their Pliocene counterparts of Asia, known nearly exclusively from jaws and teeth, are typically pongid in mandibular and dental structure and therein do not differ fundamentally from the living gibbons and great apes.

Oreopithecus, a form known for over three quarters of a century which has received much publicity and been much discussed recently, is a notable exception to this statement. This primate occurs in the Pontian (lower Pliocene) lignites of Tuscany (*100*). It is surely significant that *Oreopithecus* reveals features of dental morphology which are not *typically* pongid, although there can be no question that it is fully hominoid rather than primitive cercopithecoid (cercopithecid) (*101*). A majority of workers tend to agree that the other hominoids of the later Tertiary are typical pongids, with all the attendant dental specializations which would effectively exclude such creatures from hominid ancestry. Hürzeler's (*102*) painstaking reexamination of all the *Oreopithecus* material proves, however, that *all* later Tertiary hominoids were not typically pongid (*103*). Hence, the long-standing argument over the "cercopithecid" (Old World monkey) or "pongid" (anthropoid ape) origin of hominids can be clarified, since many of the more "generalized" hominid features which some workers have regarded as indicative of lower catarrhine affinity are present in either primitive or nonpongid hominoids. Consequently, an oreopithecine hominoid group might well provide the ancestral stage from which orthograde bipedal hominids were subsequently to evolve. It is still premature to assert the correctness of such a hypothesis to the exclusion of all others. The recent and truly important discovery of a nearly entire skeleton of

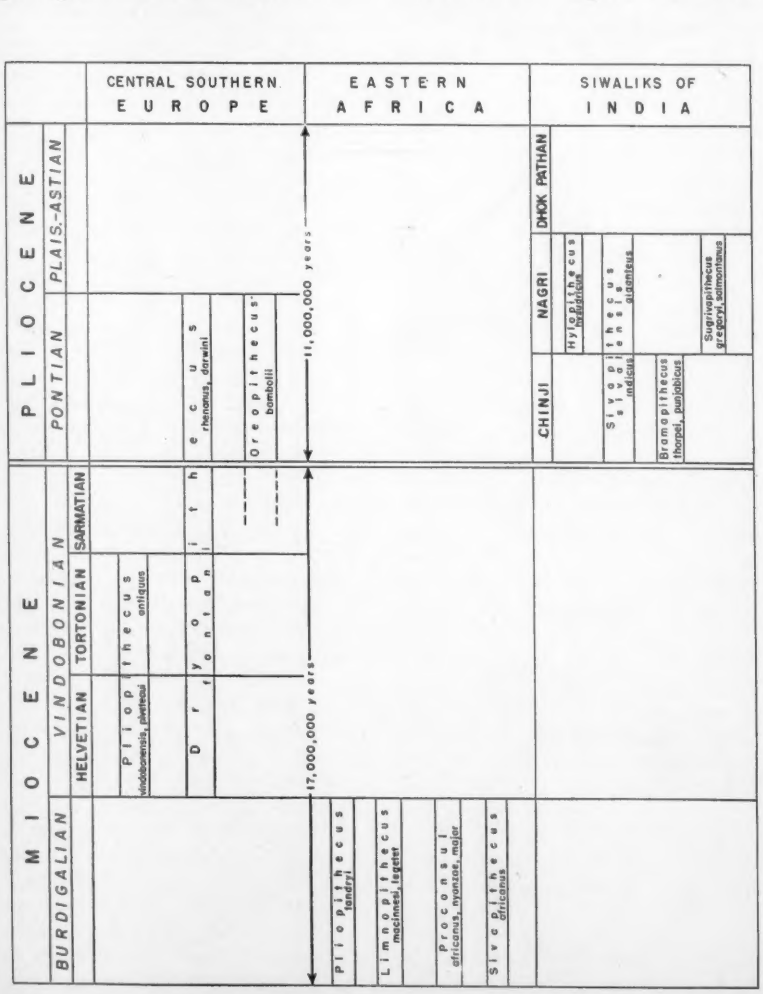

Fig. 7. Temporal distribution of hominoids in the Neogene of Africa, Asia, and Europe.

Oreopithecus from the Grosetto lignites should provide most of the evidence necessary to resolve this problem.

It should be recalled that the whole of the African Pliocene, a span of over ten million years, is still either almost or entirely unknown (*104*). Late Tertiary hominoids surely occupied the more central area of the continent, although fossiliferous deposits of this time range are still unknown. Until some evidences of hominoid varieties are forthcoming from the upper Neogene of sub-Saharan Africa, any hypotheses of hominid origins will lack support. There is widespread evidence of extensive sub-Saharan desiccation, between 1°N and 20°S, from the late Miocene throughout the Pliocene. This was a period of desertification during which great distributions of fine, light, unstratified aeolian sands of the (upper) Kalahari system occurred (*105*). Conditions appear to have been such that, except for rare, and probably small, basins of sedimentation (proto-rift valleys), which are usually obscured by volcanic lavas and other deposits, the preservation of mammalian fossils was literally precluded.

This was certainly a crucial time for mammalian evolution in general as well as for higher primate evolution in particular. Thus, the origins of the incredibly rich eastern-central African grasslands fauna is literally unknown; yet this long interval was probably vital for such a radiation, since the Villafranchian antelopes appear largely referable to existing genera. For the pongid hominoids, whose ecological requirements and habits of locomotion were apparently becoming those of forest-dwelling, vegetarian (or frugivorous) brachiators, such desiccation had profound effects on distribution, which are fully evident today in the sparse and restricted habitats of the African apes. For those hominoids that were preadapted toward terrestrial bipedalism, it was a period of trial in a new and exploitable environment. The Villafranchian stage, as well as the later Pleistocene phases of hominid history, testify to the achievement of this primary radiation.

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High-Altitude Observation Techniques

A variety of tools besides satellites are available for the study of upper atmosphere physics.

Raymond C. Staley

It may be surprising to many not acquainted with upper atmosphere research to learn that the greater part of all we know today about the structure of the upper atmosphere has been discovered without instrumented satellites. Two important bits of information provided by satellites about the upper atmosphere have so far been made public: (i) The atmosphere from 500 to 1000 km above the earth is between 16 and 40 times as dense as was thought in 1955. (ii) The soft radiation, previously detected above 50 km by balloon- and rocket-borne Geiger counters and now known to be contained in two belts at about 3000 and 14,000 km, is at least 100 times as great as was formerly believed (*1*). This survey has been prepared to explain briefly how the chemical composition, ionization, density, temperature, and motion of the atmosphere above 10 km can be studied by methods some of which use balloon and rocket instrumentation but most of which actually use ground-based observations of atmospheric phenomena.

Some Methods of Study

A classical method used to give good estimates of upper air temperatures and winds involves the anomalous propagation of sound. This method presupposes a knowledge of the molecular weight and the ratio of specific heats for the atmosphere at all levels traversed by the sound wave. The maximum height at which the wind and temperature can thus be measured is usually taken as about 50 to 60 km for ground-based explosions. With grenades exploded from rockets, the upper limit may be extended to 80 km (*2*). Sound waves with very low frequencies (0.1 cy/sec) can be bent back in the ionosphere at altitudes of about 170 km (*3*). Such sound signals can give a value for the expression

$$c_p RT/c_v m$$

where c_p/c_v is the ratio of specific heats and R/m is the gas constant for the medium. Unless these ratios are known, the temperature T (°K) cannot be found. According to Hulbert (*4*) the composition of the atmosphere is approximately constant to about 150 km, and, hence, the use of sound waves is valid for the study of temperature and wind within this region.

Winds, temperature, atmospheric composition, solar radiation, and electrical conductivity have been measured with instruments sent as high as 42 km with large balloons (*5*). Similarly, rockets have been instrumented for studies at still higher altitudes. Mass spectrographs and ion spectrographs carried aloft have provided information about the presence of argon and of atomic and molecular forms of both oxygen and nitrogen up to 220 km. Photon counters sent aloft have measured solar ultraviolet and x-ray energy available for ionization and photodissociation (*1*, *4*). In addition, other instrumentation has verified the indirectly determined vertical variation of temperature and has given much information about cosmic and soft radiation (*1*).

Before the atmosphere beyond the range of balloons is considered, some mention might be made about the study of the vertical distribution of atmospheric ozone with ground-based instruments. Götz, Dobson, and others (*6*) found means of determining the total amount and the vertical distribution of ozone. The total amount is determined by measuring the intensity of solar radiation at two different wavelengths, one at which the ozone absorption is strong, a second at which it is weak. The measurements are made at two different zenith angles. With proper measurements and laboratory-determined constants, the total ozone can be found. The mean height of the ozone layer may be estimated by studying the ozone absorption in light scattered from the zenith with the sun at various low elevations (*7*). Epstein (*8*) has presented a ground-based method for finding the vertical ozone distribution from knowledge of the total ozone content together with knowledge of the infrared absorption of solar radiation by ozone and the rate at which ozone radiates in the infrared. Paetzold (*9*) reports that a study of the sunlight reflected from the moon's surface right at the edge of the earth's shadow during a lunar eclipse will allow a determination of ozone distribution in the earth's atmosphere up to 45 km for various latitudes. The argument is that with a tangential path of solar rays there is a large decrease in the yellow-orange (Chappuis) spectral region, causing a blue-green coloring of the earth's shadow near the shadow limit. This zone represents an optical copy of the atmospheric ozone layer.

An interesting ground-based technique for finding the density distribution in the atmosphere between 10 and 70 km is the nighttime use of a modulated searchlight beam directed upward. The back-scattered light is observed from the ground at a point about 20 km from the searchlight. If Rayleigh scattering is assumed, the intensity of light will be a function of air density (*10*).

The observation of meteorites both by photographic means and by radio echoes provides considerable information about the atmosphere from 60 to 120 km. Air density, winds, and wind shear have been deduced from photographs of meteorites (*11*). Booker (*12*) states that information about atmospheric turbulence can be deduced from photographic observation of meteor trails. Atmospheric pressures and scale heights can be found from radio studies of meteor trails (*13*). Robertson (*14*) reports that a 27-megacycle-per-second

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Doppler-radio system has been used to estimate winds from meteor trail drift at 80 to 105 km; these winds appear to have prominent 12- and 24-hour tidal harmonics. Greenhow (*15*) has calculated the atmospheric diffusion coefficient by use of 8.27- to 8.35-meter radio measurements of echoes from meteor trails between 80 and 100 km.

Winds in the region between 30 and 90 km have been measured both by the observation of sound waves from grenades released from rockets (*2*, *16*) at various altitudes and by the observation of radar return from vaporized, metal-coated, thin plastic strips (chaff) released from rockets (*17*). Metallic sodium vapor ejected from Aerobee rockets during twilight hours creates a sodium emission cloud at 5890 angstroms, and observation of these clouds provides wind information at 85 to 200 km (*18*, *19*). Figure 1 shows wind-distorted sodium trails extending from an altitude of 100 km to about 200 km. Methods for computing wind velocities from such photographs have been described by Manring (*19*).

The natural phenomena known as noctilucent clouds, which occur at heights of about 80 km and apparently consist of volcanic or meteoric dust, offer some opportunities for making qualitative estimates of air turbulence and vertical stability. Ludlam (*20*) states that theodolite tracking of a noctilucent cloud element to get its velocity is difficult because these clouds usually lack elements which are well defined and which retain their identity. Rapid changes in the clouds and the presence of billows suggest a steep lapse rate and considerable stirring. Noctilucent clouds probably do not exist at latitudes less than 55 degrees, and so this source of information is limited geographically.

Ionospheric Studies

Studies of the ionosphere have provided information about the electron density and the temperature in the ionized layers; attempts have also been made to measure the size as well as the drift of the ionospheric irregularities. Radio noise should contain a component due to thermal radiation from the ionosphere, and this radiation, which is very weak, has been identified and measured (*21*); temperatures measured in this way range from 240° to 290°K. The rate of ion production at a given height is extremely sensitive to temperature changes, and so diurnal and seasonal height changes in ion-forming layers are found to correspond to diurnal and seasonal temperature changes (*22*). The daily and annual variations in F layer ionization (at about 180 km) suggest that the gradient of the temperature inversion in that layer is less in summer than in winter, and also that the warm layer is thicker in summer than in winter (*23*). Studies of the E and F_2 layers, with ionization ascribed to atomic oxygen, give temperatures of 190° to 220°K at about 110 km and 500° to 1200°K at about 250 km (*24*). The wide range is partly seasonal and partly related to solar activity, with the highest temperatures occurring in a summer of great solar activity.

Observation of radio echoes reflected from the moon shows slow variations in the mean daytime amplitude of the echoes. The plane of polarization of the radio waves is rotated due to the presence of the earth's magnetic field, and the extent of rotation depends upon the total electron content along the line of sight to the moon. J. V. Evans (*25*) explains that a technique has been developed for the deduction of the amount of rotation and thus for the determination of the total electron content.

Scintillations of radio stars have been shown to be caused by phase changes

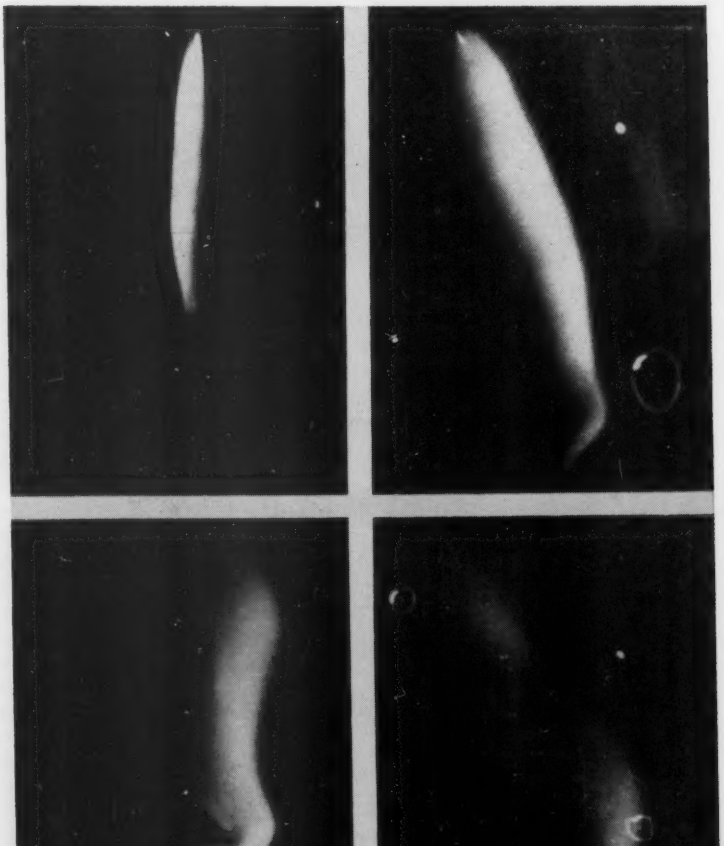

Fig. 1. Two sets of simultaneous photographs of a morning-twilight sodium trail, New Mexico, 26 November 1957. The upper pair, showing the trail over an altitude range from about 110 to 200 km, were taken when the rocket was near the zenith; the lower pair were taken about 5 minutes later. The left-hand pictures were made at Socorro, 211 km north-northeast of Deming, where the right-hand pictures were taken. [Courtesy Air Force Cambridge Research Center]

in the incoming radiation as it traverses irregularities in the electron density of the F region. The motion of ionization in the F region is probably related to turbulence and eddies in the dynamo region (135 to 150 km) through interaction between the earth's magnetic field and the electric field (*26*).

Vestine (*27*) has shown that, since geomagnetic disturbances can be represented by atmospheric electric-current systems and, in turn, the current systems can be replaced by equivalent atmospheric wind systems, it may be possible to deduce air motion in the E and F layers (100 to 300 km) from geomagnetic data.

Benyon and Goodwin (*28*) note that at about 100 km there is a high correlation between the magnitude of the drift velocity of ionospheric irregularities and the horizontal temperature gradient. This suggests that the study of the vertical structure of ionospheric drift may provide important information about the temperature of this part of the atmosphere.

Density beyond 300 Kilometers

Recent spectrographic and radio studies of the solar corona seem to support the idea that the atmosphere of the sun extends to and beyond the earth. According to Chapman (*29*) the earth and its atmosphere are immersed in this solar gas and must act as a sink of heat. Nicolet (*30*) suggests a figure for the heat conducted by atomic hydrogen from the corona to atomic oxygen in the earth's atmosphere of about 36 ergs per square centimeter per minute (as compared with the "solar constant" of about 8.4×10^7 erg/cm^2 min). Chapman's argument finds support in the comparatively large densities discovered from tracking artificial satellites and also from studying radio whistlers. Whistlers apparently are caused by thunderstorm electrical discharge (sferics) with an energy spectrum peaking in the 10- to 20-kilocycle-per-second range. The sferics travel through the ionosphere and on to altitudes of 500 to 5000 km or more, following the lines of flux of the earth's magnetic field out and then back to the opposite hemisphere. For this to occur, the average electron density of the atmosphere must be considerably greater than any previous estimates, about 400 electrons per cubic centimeter (*31*). Studies of the extension of the solar corona can be made by observing how radio waves from the radio star Taurus vary in intensity as they travel the outer corona (*32*). Since anomalies in the solar gas cloud appear to be related to changes in the earth's magnetic field, it may be possible to learn more about these anomalies by means of induced currents in transoceanic cables (*1*).

The flow of atomic hydrogen into the outer atmosphere means that the outer atmosphere must be more dense than has been thought. It is interesting to note that one piece of indirect evidence led for a time to contrary conclusions. From studies of the absorption of solar x-rays and the dissociation of oxygen up to about 165 km, some observers, by extrapolating the derived density distribution, calculated an upper atmosphere of considerably smaller density (*33*). This view was bolstered for a time by the idea (reminiscent of the early arguments about the stratosphere) that the high atmosphere should be isothermal and in radiational equilibrium. Chapman and Nicolet have countered such arguments, and the weight of evidence is for the more dense upper atmosphere above 300 km, with the temperature, as represented by the kinetic energy of the molecules, increasing with height. Here we have a case of different indirect evidence giving far different ideas about the density of the upper atmosphere. On the one hand the arguments for thermal equilibrium called for a low-density, isothermal upper atmosphere, while the observations of whistlers called for a contrary conclusion. Finally, a third indirect method, by visual, photographic, and radio tracking of the artificial satellites, provided evidence in support of the denser atmosphere. Sterne (*34*) gives a simplified formula for inferring air density at perigee from visual observations of artificial satellites. Calculations based on observations of sputnik I and reported by Harris (*35*) give an atmosphere at 400 km which is 40 times as dense as the ARDC (Air Research and Development Command) model atmosphere at that level. Later data, reviewed by Kallman (*36*), are in substantial agreement with Harris' conclusions.

A device constructed but not yet used for determining high-altitude density is the satellite balloon, a 12-foot, spherical plastic, aluminum-covered balloon carried aloft in collapsed state by an Explorer satellite. When the satellite is in orbit, the balloon is released and inflated by a bottle of gas. It then will orbit like the satellite, but air drag will act to slow the balloon more rapidly than it slows the satellite. A study of the positions of the satellite and balloon should give more information about the density of the outer atmosphere. The balloon would be large enough to be visible by eye from the earth's surface during twilight hours (*37*).

Studies of the emission spectrum of the aurora and night airglow provide information about constituents of the outer atmosphere. The aurorae are most frequent at heights of 100 to 120 km, but they are observed from 63 to 400 km. Sunlit aurorae may occur as high as 1100 km (*38*, p. 422). Atomic oxygen, nitrogen, and hydrogen, the oxygen and nitrogen ions, O_2^+ and N_2^+, and molecular oxygen and nitrogen have all been observed in aurorae. Seaton (*39*) has estimated the N_2/O ratio for heights between 160 and 400 km. He also gives an N_2^+ density above 740 km as greater than 120 ions per cubic centimeter. The night airglow emission is known to originate at heights from 70 km (OH) to 1000 km (oxygen) (*38*, p. 533). Its spectrum, which shows atomic oxygen and sodium, the N_2^+ ion, molecular oxygen and nitrogen, and the OH radical, runs from the violet well into the infrared (10 μ). At one time it was thought that the infrared emission was caused by the recombination of atomic nitrogen, but this emission is now attributed to vibration-rotation bands of hydroxyl (*40*). Phillips (*41*) has observed the width of the oxygen emission line 5577 A in the airglow and the line 6300 A in the twilight flash. These line widths indicate temperatures between 155° and 231°K at 100 km for the former and a temperature of about 750°K for the latter at about 220 km. Studies of the translation and rotation of airglow cells (5577 A emission) have convinced personnel at the University of Colorado High Altitude Observatory that these motions represent true winds at 100 km (*42*).

Conclusions

From this brief survey of some methods available for upper atmosphere research, it appears that there are many tools of widely varied complexity which can be used for such work. Most of these need further research and development. It would seem wise to use the most promising of the indirect measurement techniques near rocket-launching areas and to make the measurements synoptic with rocket studies. It is also

important that measurements of the outer ionosphere be matched with satellite data. It is not unlikely that, once certain relations are verified, ground-based observations will be capable of providing hour-by-hour and day-by-day information about the upper atmosphere which would be much too costly to obtain routinely with rockets. Furthermore, some of the indirect methods will permit routine measurements from regions too close to the earth for observations with long-lived satellites.

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Science in the News

Khrushchev Sees Aspects of American Science and Talks About Soviet Achievements

Soviet Premier Nikita S. Khrushchev's trip to the United States closed further the narrowing gap between science and politics. In his statement on arrival, the Premier made the first of many scientific references when he spoke of the Soviet moon rocket and of his country's newly launched atomic icebreaker. Of the moon rocket, he said:

"Shortly before our meeting, Mr. President, the Soviet scientists, engineers, technicians and workers filled our hearts with joy by launching the rocket to the moon. . . . A container . . . with a pennant bearing the national emblem of the Soviet Union is now on the moon. . . . We entertain no doubt that the splendid scientists, engineers and workers of the United States of America who are engaged in the field of conquering the cosmos will also carry their pennant over to the moon. The Soviet pennant, as an old resident of the moon, will welcome your pennant, and they will live there together in peace and friendship as we both should live together on the earth. . . ."

The atomic icebreaker that was mentioned is the 16,000-ton *Lenin*, which started its maiden voyage on 15 September, the day that Mr. Khrushchev arrived in the United States for his 12-day stay. The ship, which can carry enough fuel to cruise for several years, is designed to keep open the 11,000-mile arctic sea route between Murmansk and Vladivostok—a route at present open about 10 weeks each year.

Disarmament Plan Offered

Disarmament, including a nuclear-test agreement and cooperation in the peaceful use of atomic energy and outer space, was a persistent theme in virtually all of the Soviet Premier's speeches. He set the stage for his total disarmament proposal to the United Nations when he addressed the National Press Club in Washington on the second day of his visit. He said:

"The best, the most reliable way to make war impossible would be to place all states, without exception, in conditions where they would have no means of conducting war. . . .

"The Soviet Union and the United States are faced with this alternative: Either the latest achievements of scientific and technical thought—the discovery of the secret of the atom, the development of rockets and the penetration of outer space—will be placed

in the service of a peaceful future and prosperity of mankind, or they will be used for the purpose of destruction and annihilation and, as a result, the earth will be covered with ashes and graves. The Soviet people have long made their choice for peace."

Next day he repeated these views in a general discussion of peaceful coexistence before the members of the Senate Foreign Relations Committee and guest senators.

During an hour-long question period, Senate Majority Leader Lyndon Johnson (D-Tex.) asked whether the Soviet Union is willing to exchange secrets on space flight. Mr. Khrushchev replied that he does favor such exchange. When Johnson pressed him then as to why the Soviet Union had not participated in the U.N. *ad hoc* committee on this subject, he said that the United States had attempted to put the Soviet Union into the position of a "poor relation," that the Soviet Union had not been treated with the proper respect in this area, and that it was a subject on which the two powerful countries active in the field could agree.

On the following day, 18 September, the Soviet Premier gave the United Nations his 4-year plan for general and complete disarmament of all states. Some of the scientific aspects of the plan are as follows:

"All atomic and hydrogen bombs . . . will be destroyed and their further production terminated. The energy of fissionable materials will be used exclusively for peaceful economic and scientific purposes.

"Military rockets of all ranges will be liquidated and rocket facilities will remain only as means of transportation and harnessing outer space. . . . The stockpiles of chemical and bacteriological means of warfare accumulated by some states . . . will be eliminated once and for all. . . ."

Later in the address Khrushchev considered control, proposing the establishment of an international body to set up a system of control over all disarmament measures. After first stating that the Soviet Government would not resume nuclear tests if the Western powers do not resume theirs, he said:

". . . The elaboration of a program of general and complete disarmament should not hold up the solution of such an acute and fully mature question as that of the discontinuance of nuclear weapons tests for all time. There now

Premier Khrushchev visits the Agricultural Research Center in Beltsville, Md., where he hears John W. Mitchell explain how chemicals can regulate plant growth and examines a cow especially bred for high milk production.

exist all prerequisites for such a solution. We hope that the appropriate agreement on the discontinuance of tests will be concluded and put into effect without delay."

Initial reaction in the United States to the disarmament proposals was restrained. Most official observers were reluctant to comment, except to suggest that at important points the plan was vague. Interest was expressed, however, in Mr. Khrushchev's test-ban remarks. Some observers, such as Senator Hubert H. Humphrey, chairman of the Senate Subcommittee on Disarmament, felt that these comments offered an unparalleled opportunity to initiate a disarmament control system. Others, such as Senator Clinton D. Anderson, chairman of the Joint Committee on Atomic Energy, have indicated that it would be wiser to attempt only a limited agreement, one which would permit continued testing underground without inspection.

The interrelationship of science and public affairs was demonstrated not only by words but also by Soviet Premier Khrushchev's itinerary, which listed an impressive number of research laboratories and agricultural and technical installations.

Beltsville Visited

Because increasing Soviet food production is a major aspect of the U.S.S.R.'s national policy, and because Mr. Khrushchev was in charge of Russian agriculture before he became Premier, it is not surprising that one of his first actions was to inspect the Department of Agriculture's Agricultural Research Center at Beltsville, Md. He paid a long visit there on 16 September.

In a slightly barbed welcoming speech, Secretary of Agriculture Ezra Taft Benson praised the progress of American agriculture "under our capitalistic free-enterprise system." He noted the cooperation in farm research between federal and state specialists and those in private industry, and called the family farm the "backbone of American agriculture."

The Secretary then turned the program over to some of the department's scientists in the Bureau of Plant Industry. Harry A. Borthwick recently helped discover a form of plant pigment that controls growth. He described how plant growth can be promoted or inhibited through the pigment by exposure of seed and plants to light. Next, Warren C. Shaw discussed a new weed killer that does not harm cereal crops and legumes. John W. Mitchell, shown in one of the accompanying pictures, displayed some results of the application of growth-regulating chemicals to plants, fruits, and trees.

After the lectures, Mr. Khrushchev told Secretary Benson that he thought the Soviet Union could benefit from American agricultural research. He also suggested that there should be an increase in the exchange of technicians.

The last part of the Beltsville visit was spent inspecting the experimental livestock, about which the Premier exhibited considerable knowledge. He is shown examining a cow which, during a 305-day lactation, produced 18,000 pounds of milk and 724 pounds of butterfat. Her forebear, eight generations back, produced only 15,800 pounds and 540 pounds, respectively.

Mr. Khrushchev saw the practical application of scientific farming on 23 September when he went to Iowa to inspect Roswell Garst's hybrid-corn farms and experimental growing plots. The Premier paid particular attention to chemical fertilizers, synthetic feeds, and new machinery. Garst's hybrid seed was exported to the U.S.S.R. in great quantity and opened the way for Soviet introduction of modern corn-farming techniques.

The Premier concluded the agricultural aspect of his tour with a visit to Iowa State College, Ames, a major agricultural research center.

Research Secrecy Discussed

While he was in California, Mr. Khrushchev toured the International Business Machine's computer plant, where he gave some of the workers souvenir medals commemorating the Soviet moon rocket. Later, when he discussed his IBM visit at a joint dinner of the San Francisco Commonwealth Club and the World Affairs Council, he turned to the topic of secrecy in research, saying:

"The plant we saw was making computers . . . I don't know who makes the better machines. . . . For the time being we're keeping them a secret. . . . Both sides are actually keeping them a secret for the time being. . . . But I am sure that the time will very soon come when there will be no such secrets and people will be able to see all such machines and benefit by them."

Two Major Visits Canceled

During the California stay, Mr. Khrushchev was also scheduled to see the Stanford Research Institute at Menlo Park, but time would not permit and he sent three delegates instead, including Vasily S. Yemelyanov, chief of the Main Administration for the Use of Atomic Energy. The projects shown to the Soviet officials included such subjects as research aimed at finding chemicals to cure cancer, efforts to improve the use of radar to give early hurricane warnings, a machine that uses principles of television to give a high-speed facsimile reproduction process, and research on opportunities for the private investment of capital in foreign countries.

Mr. Yemelyanov is reported to have found it difficult to understand that the institute was organized to sell research services in any field wanted by governmental or private customers. He commented that in the Soviet Union, research is organized for a specific purpose, such as the creation of better airplanes or the conquest of a disease such as cancer.

A second major scientific visit that the Premier was forced to cancel was that to the National Institutes of Health in Bethesda, Md., where an elaborate 1½-hour program had been prepared. A. M. Markov, chief of the Soviet Medical Service, and Dr. V. N. Butrov, of the Soviet Foreign Ministry, went in his place. Before leaving, Markov commented that American and Soviet medical people should join in eliminating disease in all countries:

"Our two countries are more or less equal economically. And if our doctors could get together, we could do very much for the peoples of all nations."

Next day, on 26 September, H. van Zile Hyde, Assistant Surgeon General for International Affairs, announced that the United States and the Soviet Union have agreed to engage in joint health-research projects in cancer, heart disease, and poliomyelitis. This group of projects is the first major cooperative effort in peaceful scientific pursuits to be announced as a result of the Premier's visit to this country.

Mr. Khrushchev's tour of the United States was set in historical perspective by the French paper, *Paris-Presse*, which quoted a comment Lenin made in 1920 to H. G. Wells. Lenin had just read one of Wells' science-fiction books, and is reported to have said:

"I, too, understand that all human conceptions are on the scale of our planet. They are based on the assumption that technical potentials, when

developed to the full, will not go beyond 'terrestrial limits.' If we arrive at establishing interplanetary communications we must revise all our philosophical, social, and moral conceptions. In that case the technical potentials, having become unlimited, will impose upon us the end of violence as a means and method of progress."

House Committee Questions Adequacy of Manpower Roster

In a report last month, the House Science and Astronautics Committee, headed by Overton Brooks (D.–La.), expressed reservations about the completeness and currency of the National Science Foundation's Register of Scientific and Technical Personnel. In criticizing the register, the report cited NSF studies that estimated that there are approximately 300,000 persons in the United States who would qualify under a generally acceptable definition of the term *scientist*. The committee juxtaposed this figure to the 170,000 the register now lists. Questions were also raised about the value of dated information on individuals whose profession is characterized by frequent changes of place of employment and field of investigation. Unable to decide whether the register was receiving sufficient support and planning, the committee asked the Science Foundation to report to it next January.

Answers to the committee's questions are currently being worked up for the NSF report in January. The foundation's position is that "very considerable progress" has been made in the register program. In testimony given during the last sessions of the hearings, NSF spokesmen cited the doubling of funds allotted for the program by the foundation for fiscal years 1959 and 1960. New and larger quarters have been acquired for the Records Center in Raleigh, and additional tabulating and microfilming equipment has been installed. Studies are under way on the problem of speeding up the processing of data as they arrive.

A simpler questionnaire is being prepared and plans are being developed to make the register better known and to make its data more readily available to participating scientists through professional societies.

Although the House committee and the Science Foundation have disagreed on some matters of interpretation concerning the register, the basic attitude is one of cooperation. The committee is aware of the difficulties that the register faces, some of which stem from the way Congress itself operates. For example, the House Committee on Science and Astronautics may want the register expanded, but it does not follow that the House Committee on Appropriations will give the Science Foundation the necessary funds. As Chairman Brooks himself noted, at the very time the spring hearings on NSF's division of scientific manpower and education were being conducted, the House Committee on Appropriations recommended a cut—later restored—in funds for the unit.

Radio Frequencies for Research Studied at Geneva

The allocation of radio frequencies for research in space is one of the major issues now before a 3-month-long conference of the International Telecommunications Union at Geneva. Radio astronomy and space communications, two fields that have expanded greatly since the last ITU conference in 1947, are the particular subjects of study of the 708 delegates at the conference, which began 17 August and will continue until 17 December. The ITU, a U.N. organization through which countries regulate international telecommunications, is using the long session to overhaul the regulations drawn up in 1947. Rapid technological change in recent years and the opening of new fields of communication led to the current sessions.

On the opening date of the conference, the United States delegation presented its position on the problem of frequencies for radio astronomy. After citing the increasing value of the new science's findings, the U.S. group proposed that a world-wide allocation to radio astronomy be made of the frequency band 1400 to 1427 megacycles per second (Mcy/sec). This band, also called the interstellar hydrogen line band, is the major one used in radio astronomy. Another proposal, put forth by the Netherlands delegation, specified a range from 1399 to 1427 Mcy/sec. Virtual agreement among the conferees is reported on the protection of a band at least as wide as that in the U.S. proposal. The U.S. paper also cited measures taken to afford national protection to radio astronomy observatories in this country.

In another action, the U.S. delegation proposed that six frequencies be set aside for space communications. These communications would be between the earth and satellites, and between satellite and satellite. The frequencies, which would be used for tracking, guidance, and telemetering of data, are: 1700 to 1725, 1825 to 1850, 2275 to 2300, 8300 to 8400, 15,150 to 15,250, and 31,500 to 31,800 Mcy/sec.

Some Opposition

The assignment of radio frequencies for research is not an easy matter, according to reports on the conference. Many conflicts come up that require extended negotiation. In the assignment of frequencies for space communication, for example, some opposition was registered by the delegation from the Soviet Union on the grounds that such allocations at this time would be premature. Pressure from the other delegations moved the Russian group to ask for more time to study the proposals. A number of organizations, particularly military and commercial users, object to the assignment of frequencies for research because the bands might be needed in the future for nonresearch uses. Conference proceedings are aided, however, by a considerable body of accepted practice that has accumulated during the years the ITU has been in existence. Because of this common body of accepted practice, the Union, which was formed by the merger of two of the oldest inter-governmental organizations in the world, generally manages to resolve the conflicts that arise.

Health Research Grant Practices Held Satisfactory

Large increases of funds for the National Institutes of Health will not result in a lowering of the quality of the research projects supported by NIH, spokesmen at the Bethesda, Md., facilities report. The review process for grant requests, and the growing volume of requests for funds for medical research, officials say, assure that the new funds will be used wisely.

Last August, President Eisenhower expressed some concern on this point when he signed the appropriations bill for the Department of Health, Education, and Welfare under which NIH

operates. Although his dissatisfaction was not sufficient to make him veto the bill, which increased NIH's funds from $294 to $400 million, he did indicate that he had reservations about the wisdom of a 36 percent increase in funds for a single year. His first concern was that the large increase should "lower the quality of the projects supported by increasing the flow of grant applications more rapidly than the procedures for their careful appraisal can be effectively adapted." He directed the Secretary of Health, Education, and Welfare and the Surgeon General to take appropriate steps to assure themselves that any new research projects be of "high priority and great promise." The President's reservations and his directives to the officials of the department turned the spotlight squarely on the procedures of evaluation that now exist in NIH. Are they adequate now? Will they be changed or expanded?

The NIH grant evaluation process, with its commentary on individual grant requests by study sections, rating of them by advisory councils, and approval by the Surgeon General of as many of the highest-rated projects as the money allows, has been in operation since 1946 when it was devised by C. J. Van Slyke, now Deputy Director of the Institutes. In the opinion of NIH spokesmen, the system has informally been doing the job that the President formally directed the officials of the Department of Health, Education, and Welfare to do in his statement when he signed the appropriations bill. The effect of the growing appropriations for NIH, spokesmen say, is that the Surgeon General's office will be able to go lower in the stack of grant requests. But, because of the very large number of the grant applications and the stringency of the review process, NIH officials feel, standards will not suffer and the new money will go to research projects that will add significantly to the public health.

Congress Leaves Conservation Issues for Next Year

Members of the 86th Congress brought their first session to an adjournment on 15 September and left most of the important conservation legislative issues for the second session that will begin in January. The National Wildlife Federation reports that, although the session did not result in any outstanding conservation accomplishments, several measures were brought along to points where final action may be expected early next year.

Among the major conservation bills under consideration, that strengthening the Federal Water Pollution Control Act probably made the most progress. This measure to protect streams from raw sewage pollution (H.R. 3610) was sponsored by Representative John A. Blatnik (Minn.). It passed the House, 255 to 143, and won approval in the Senate by a 61-to-27 margin. The House version of the bill, however, would increase the program of grants for the construction of municipal sewage treatment works from $50 million to $100 million annually for 10 years, while the Senate voted only $80 million. Differences in the measures were being considered in a Senate-House conference committee at adjournment time, and the compromise version probably will be among the first sent to the President next year.

Soil Bank and Pesticide Awards

After lengthy discussion, Congress granted $375 million—the same amount as last year—for the Conservation Reserve Soil Bank program, a program for reducing surplus agricultural production. Under the Soil Bank, farmers lease land to the Federal Government, which uses it for wildlife preserves or other purposes. Last year 23 million acres were retired under this plan at a cost of $375 million. If this land had been planted, it would have cost the government $600 million just to store the surplus produced. An even greater controversy over the Soil Bank can be expected in the next session, for the act authorizing the program expires at the end of the 1960 calendar year and must be extended if the plan is to continue. Measures to extend the authorization have been introduced but have not yet received serious consideration.

Congress also approved S. 1575 authorizing the expansion of the Fish and Wildlife Service research program into the effects of pesticides on fish and wildlife. The measure, which contains a maximum authorization of $2,565,000 per year, was signed by the President on 16 September. Efforts by conservationists to knock out the $2.4 million Department of Agriculture appropriation for fire ant "eradication" failed, however. This program has a serious detrimental effect on fish and wildlife, and other organisms.

Other Measures Held Over

One of the few major conservation measures not involved in budgetary considerations—the Wilderness Bill to preserve public lands (S. 1123)—was included in the legislation held over until the second session. Although it has not yet been voted on by committees in either the Senate or the House, much groundwork was laid toward working objections out of the bill and in holding extensive field hearings. Action by the Senate Committee on Interior and Insular affairs is expected early next year.

Among other measures to be held over into the second session are: S. 812, to establish a Youth Conservation Corps, which has passed the Senate; S. 1262, to authorize large impoundment fisheries research, which has passed the Senate; H.R. 2565, the Sikes Bill to authorize fish and game programs on federal military reservations, which has been reported by the House Merchant Marine and Fisheries Committee; H.R. 7045, to establish the huge Arctic Wildlife Range in Alaska, also reported by the House Merchant Marine and Fisheries Committee; and S. 2086, to establish a wildlife disease laboratory, which has been reported from the Senate Interstate and Foreign Commerce Committee.

National Medical Library Interlibrary Loan Program

It is now 2 years since the new interlibrary loan policy of the National Library of Medicine went into effect. During fiscal year 1959 the National Library of Medicine filled over 6000 interlibrary loan requests each month, and there are many indications that the volume of business will continue in a steady rise.

Two-thirds of all interlibrary loan requests received at the National Library are now being completed within 5 working days. A major objective of the program has been attained in that the percentage of publications "unavailable by reason of being already on loan" has dropped from 33 percent in 1957 to 18 percent in 1958 and to 12 percent in 1959.

The proportion of interlibrary loans being furnished to foreign libraries (one request out of every seven) has remained about the same this year as last. The number of such loans amounted to 10,000 in 1959, leading to speculation as to whether the various national facilities are being fully exploited.

Copies of a revision of the National Library of Medicine's interlibrary loan rules may be obtained on request.

Women in the Class of 1957

For the third successive year, the Women's Bureau of the Department of Labor, with the cooperation of the National Vocational Guidance Association, has conducted a survey of first jobs of women college graduates—nearly 88,000 of them for June 1957. A small percentage had gone on to graduate work, either full or part time—principally in education. Teaching also was the most popular profession of the working graduates, 42,000 being employed in that profession.

In the social, physical, and biological sciences and in mathematics and engineering, however, where many excellent opportunities exist for college women, the numbers were disappointing. Only 586 women had jobs as chemists and 703 as mathematicians and statisticians, or 1.8 percent of employed graduates. "Technicians, biological," represented 2.8 percent.

Since first jobs were largely in fields related to undergraduate majors, it becomes obvious that women are still not aware of the expanding opportunities in the scientific professions. This report by Jean A. Wells of the Women's Bureau emphasizes the importance of proper counseling if young women are to fulfill their individual goals and be of maximum service to society.

A comparison of salaries by occupation reveals that girls who went to work as chemists were the elite of the group, starting at an average annual salary of $4847. Mathematicians and statisticians did almost as well at $4675, and biological technicians commanded an average annual salary of $3854. The over-all annual average was $3739 (an increase of $598 since 1955, the first year in which a survey was made). Women who entered journalism were almost as badly paid as typists and clercial workers.

Crerar Library Merger Announced

Merger of the John Crerar Library, one of the world's largest collections of scientific and technical literature, with the Illinois Technological Institute has been announced. The Crerar Library will be housed in a $2-million public library building to be constructed on the institute's campus.

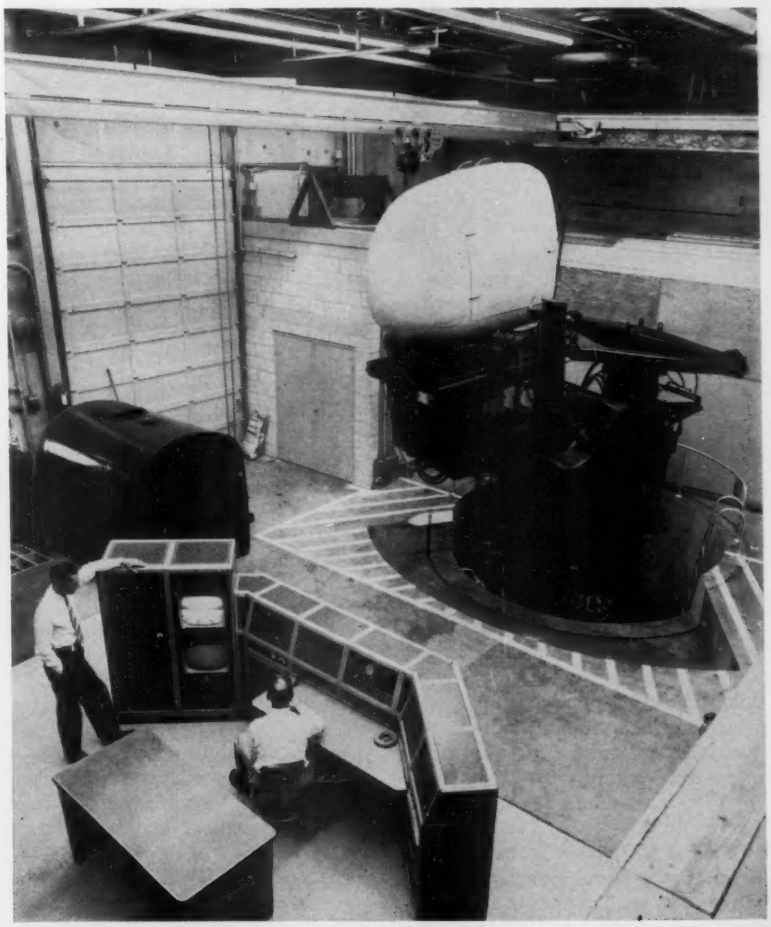
As a result of this consolidation, the Crerar Library will have a staff of 85 people. With increased facilities and personnel, it is planning improved and expanded services and hopes to realize substantial economies in library operations. At the same time, the merger will permit the institute to provide increased library services and reference sources for its students, faculty members, and scientific personnel, who comprise at this time Crerar's largest single group of users.

The library will remain under the administration of the Crerar board of trustees and will continue to serve the greater Chicago area in its present capacity. Custody of Illinois Tech's estimated 125,000 scientific and engineering books and periodicals will be assigned to the Crerar Library. The library, with its current inventory of some 1 million books and periodicals of all classifications, plus this acquisition, will have one of the most comprehensive collections of scientific and technological documentation in the United States.

New Helicopter Flight Simulator

A helicopter flight simulator has been developed jointly by the Franklin Institute and the Bell Helicopter Corp. of Philadelphia, Pa. It was built primarily for human engineering studies required in the Army-Navy Instrumentation Program. Because of the problems associated with flight safety, weather, and weight limitations of the helicopter, observation of human performance in actual machines is difficult.

The new simulator can reproduce the motion, sound, vibration, and general cockpit arrangement of most existing helicopters. The pilot operates the test machine as though he were flying a real ship under blind-flight conditions, so that new controls and instruments can be evaluated before being included in a research plane.



The new helicopter flight simulator designed by the Franklin Institute of Philadelphia is used by engineers of the Bell Helicopter Corporation's Army-Navy Instrument Program to evaluate new controls and instruments before they are installed in research helicopters.

Scientists in the News

Donald R. Chadwick, career medical officer of the Public Health Service, has been appointed secretary of the new Federal Radiation Council. Chadwick's appointment was recommended by George B. Kistiakowsky, Special Assistant to the President for Science and Technology and adviser to the Federal Radiation Council.

Pearce Bailey, director of the National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Md., has been appointed director of the institute's new International Neurological Research Programs. **Richard L. Masland,** assistant director, will succeed Bailey as director of the institute.

Hilliard Roderick, nuclear physicist in the Controlled Thermonuclear Branch of the Research Division of the U.S. Atomic Energy Commission, has been appointed deputy director of the Natural Sciences Department of the United Nations Educational, Scientific, and Cultural Organization's secretariat in Paris. He started his 2-year assignment in September.

Herbert G. Andrewartha of the University of Adelaide, Adelaide, Australia, has been appointed visiting professor of zoology at Duke University for the fall semester. He will deliver a series of 30 lectures on the physiological aspects of animal distribution.

Sidney H. Liebson, manager of the research and development operations of the Nuclear Development Corporation of America, has been appointed assistant director of physics research at the Armour Research Foundation of Illinois Institute of Technology.

Chester E. Poetsch, head of the pharmaceutical chemistry section of Smith, Kline and French, has been appointed research director of Vick divisions, Vick Chemical Company, New York. He will be vice president of research for Vick Products Division and for Vick International Division.

William C. Coombs, communication engineer, has been appointed chief of the systems analysis section in the Radio Communication and Systems Division of the National Bureau of Standards' Boulder Laboratories, Boulder, Colo.

William E. Adams, James Nelson and Anna Louise Raymond professor of surgery at the University of Chicago, has been appointed chairman of the department of surgery.

Henry P. Wheeler, Jr., chief of the Helium Liaison Office of the U.S. Department of the Interior, has been appointed assistant director of the department's Bureau of Mines, to administer helium activities. He succeeds **Clifford W. Seibel**, who retired on 31 August.

Also at the Department of the Interior, **Paul V. Mullins**, chief of helium operations, has been appointed general manager of helium operations, with headquarters at Amarillo, Tex.

George L. Curran, associate professor of medicine and gerontology at the University of Kansas Medical School, has been appointed associate professor of internal medicine at the St. Louis University School of Medicine. He will direct the section of preventive medicine and public health of the department of internal medicine.

Lee A. DuBridge, president of California Institute of Technology, delivered four lectures, entitled "An Introduction to Space," at Brookhaven National Laboratory, the first in the honorary Pegram lectureship series. The lectureship has been established in the name of the late George B. Pegram, outstanding nuclear physicist and dean of Columbia University, who played an important role in the founding of Brookhaven.

Morris Cohen, professor of physical metallurgy at Massachusetts Institute of Technology, will receive the Francis J. Clamer Medal of the Franklin Institute, Philadelphia, Pa., on 21 October.

Sidney Golden, professor of chemistry at Brandeis University, will spend the coming year at Cambridge University, in the department of theoretical chemistry.

W. A. D. Anderson, professor and chairman of the department of pathology at the University of Miami School of Medicine, Miami, Fla., has received the annual award of the Scientific Products Foundation for the most outstanding contribution to the improvement of laboratory techniques. The presentation took place at the annual meeting of the College of American Pathologists, in Chicago.

Arnold W. Frutkin, secretary to the International Relations Committee of the Space Science Board of the National Academy of Sciences, has been named director of the National Aeronautics and Space Administration's Office of International Programs. He succeeds **Henry E. Billingsley**.

Michael J. S. Dewar, professor and head of the department of chemistry at Queen Mary College, University of London, England, has been appointed professor of chemistry at the University of Chicago.

Charles D. Coryell, professor of chemistry at Massachusetts Institute of Technology and cofounder of the Nuclear Science and Engineering Corp., Pittsburgh, Pa., is the recipient of the American Chemical Society's 1960 Award for Nuclear Applications in Chemistry.

Jean F. Piccard, professor emeritus of aeronautical engineering of the University of Minnesota, has been honored by the American Meteorological Society for his work in the development of balloons for atmospheric research.

Recent Deaths

Sir Ian Heilbron, London, England; 72; specialist on the chemistry of vitamins A and D and on penicillin; had held chairs of organic chemistry at Liverpool University, Manchester University, and the Imperial College of Science and Technology, London; 14 Sept.

Walter B. Kiener, Lincoln, Neb.; 64; botanist and lichenologist; formerly biologist for the Nebraska State Game, Forestation, and Parks Commission; 24 Aug.

Frederick S. Mallette, Riverside, Conn.; 53; specialist on air-pollution control; executive secretary of the Committee on Air-Pollution Controls of the American Society of Mechanical Engineers; 10 Sept.

Arthur Pap, New Haven, Conn.; 37; associate professor of philosophy at Yale University; 7 Sept.

William C. Stadie, Narberth, Pa.; 73; specialist on diabetes; John Herr Musser emeritus professor of research medicine of the University of Pennsylvania; developed an arterial puncture for the study of respiration and cardiac disease and one of the first oxygen tents for the treatment of pneumonia; 11 Sept.

Book Reviews

Asa Gray. A. Hunter Dupree. Belknap Press of Harvard University Press, Cambridge, Mass., 1959. 506 pp. Illus. $7.50.

Almost every botanist in the United States has, as a student, used Asa Gray's *Manual of Botany*, which is still one of the more useful aids for studying the flora of our northeastern states, and still a very useful tool for teaching students how to identify plants. To beginning botanists, "Gray" is practically synonymous with *Manual of Botany*. Biologists who are interested in evolution (and in 1959, the 100th anniversary of the publication of Darwin's *Origin of Species*, nearly all biologists are) know that when Darwin and Wallace presented their famous papers to the Linnaean Society of London, Darwin included in his, as evidence for his priority in describing natural selection, a letter he had written to Asa Gray. Today, we remember Gray both as a leading systematic botanist of the 19th century and as a personal friend of Charles Darwin —a friend who aided Darwin in establishing and spreading the theory of evolution. How much more there was to Asa Gray, what kind of a man he really was, and what he accomplished as a scientist is told in this remarkably well-written biography by Hunter Dupree.

Now the life of a respectable 19th-century botanist, who labored over his *desiccata* ("baled hay" to irreverent scoffers), who collected specimens over a wide territory, who assembled a herbarium, and who named new genera and species, may be deadly dull even though the subject of the biography may have engaged in the no-holds-barred and no-quarter-given fights over nomenclature. To both students and teachers, reading the biographies of such worthy men may be an unpleasant but necessary chore. But reading this life of Asa Gray is no chore at all. It is a pleasure; in fact, the author has made his book so interesting that most readers will resent, rather than welcome, any little incident that interrupts them. *Asa Gray* is an excellent example of the kind of writing that has recently made biographies so popular.

This is not intended to imply that Dupree has fictionalized his subject. On the contrary, he has documented it thoroughly by citing over 800 references to primary sources, and if he peers into the subject's mind at times and tells us exactly what Gray's thoughts were, he is always able to cite Gray himself as the authority. In this biography Gray definitely comes alive. But, perhaps, despite his narrative skill and mastery of his subject we need not give the author all of the credit for the interest that this book arouses, for Asa Gray cooperated with his biographer by leading a very interesting life.

Gray was born in 1810 in Sauquoit, New York, and grew up in the central valley, at just the time that the first educational institutions of the region were being established. He became a doctor of medicine in 1831, but practiced only a little more than a year. His primary interests were always those of a naturalist, and he spent all the time that he could spare in gathering botanical, zoological, and mineral specimens. He had the good luck to meet and fall under the influence of John Torrey and, in working with Torrey, he became an expert taxonomist. After some years of odd jobs and financial insecurity, but years of productive scientific labors, he established an outstanding reputation as a botanist, and in 1842 was offered an endowed chair at Harvard University, where his salary of $1000 a year relieved his financial insecurity. But, to earn his stipend, he had to become a one-man department of botany. He taught botany, established what later became the Gray Herbarium, and supervised the Harvard Botanic Garden. But over and beyond these routine occupations, he indulged his wider interests and spent as much time as he could in identifying and classifying the western plants sent him by various governmental exploring parties.

As Gray's knowledge of the American flora increased, he discovered regularities in the distribution of certain genera and species, and his interest in plant distribution grew. In fact, he was one of the founders of plant geography, and it was in this field that his very original work came to the attention of Charles Darwin. It was here that, without knowing it, he made an important contribution to the theory of evolution. Gray and Darwin exchanged letters and became close, personal friends, and when Darwin published *The Origin of Species*, Gray reviewed it and saw to it that Darwin got a fair hearing in the United States. Gray was Darwin's first American sponsor.

From a personal standpoint, Gray's long and sometimes bitter contest with his Harvard colleague, Louis Agassiz (who did *not* accept Darwinian evolution) furnishes the material for perhaps the most interesting portion of the book. Here, we get a glimpse of academic politics, of the growth of science in the first American university, and of the establishment of the National Academy of Sciences. We also get a view of contemporary scientific standards.

Attention should be called to two aspects of this biography that are not adequately expressed in its brief title, *Asa Gray*. First, Dupree's treatment transcends Gray as an individual and depicts, in fascinating detail, the alarms and excursions of 19th-century biology. Dupree makes the science of the time very real, and the actors—the scientists —very human. Finally, he gives us a great many important facts about the group of men who worked with and around Charles Darwin—Sir Charles Lyell, Thomas Henry Huxley, Joseph Hooker, Alfred Russell Wallace and others—the group that introduced evolution to the world. Gray was a very important member of this group.

This biography of Asa Gray is definitive.

CONWAY ZIRKLE
Botanical Laboratory, University of Pennsylvania

Law and Administration. vols. 1 and 2. Herbert S. Marks, Ed. Pergamon Press, New York, 1959. xiii + 994 pp. $26.50.

This work is an authoritative and comprehensive source of background information in the field of atomic energy. The tenth of 12 subject categories in the ambitious series "Progress in Nuclear Energy," the work is in two

volumes. Volume 1 presents authoritative articles on specific aspects of law and administration relating to the nuclear-energy programs of the United States, the United Kingdom, Euratom, the International Atomic Energy Agency, and Israel. Volume 2 presents the texts of nuclear-energy legislation and regulations in effect in 25 countries, together with succinct commentaries on the history and status of atomic-energy control in each country.

Each chapter in volume 1 is written by a recognized authority. These chapters present a distillation of the history, conflicts, compromises, and status of the new legal and administrative arrangements that have evolved, primarily in the United States and Britain, as governments respond to the new nuclear technology. John Palfrey's opening chapter is an excellent "legal chronicle" of the United States federal statute, while William Krebs' chapter on state activities and Casper Ooms' chapter on patents are clearly indicative of the authors' deep understanding of the subject matter. I wish that chapters had been included on the new administrative arrangements evolving out of AEC-contractor relationships, or that there had been more specific material concerning the growing federal-state-local problem of licensing and control of private atomic-energy facilities. These are minor criticisms, however, of a noteworthy treatise.

Volume 2, except for the commentaries, is a reference source on foreign legislation and procedures—clearly of limited interest to all but the specialist. The commentaries are useful summaries.

JOHN R. MENKE
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The Emergence of the German Dye Industry. John Joseph Beer. University of Illinois Press, Urbana, 1959. vii + 168 pp. Cloth, $4.50; paper, $3.50.

This detailed account of the German dye industry begins with Perkin's discovery of mauve dye (analine purple) and terminates with the formation of the I. G. Farbenindustrie. It is less a history of the scientific and technical development of the industry than an analysis of the social, economic, and scientific factors which brought about that most spectacular chapter in the extraordinary history of the chemical industry in the 19th century.

It is surprising that this story has not previously been recounted in English, especially since the German dye industry has been celebrated in the United States as an example of commercial and scientific iniquity. It is the more surprising inasmuch as a considerable number of general histories, company histories, and personal memoirs on the subject in German have long existed.

From this account, the *bête noire* appears to be little worse or better than the rest of us. In fact, while the influence of the chemical industry on German technical education and the patent system was instrumental in securing the initial advantage Germany enjoyed in World War I, Beer concludes that the failure of the German chemical industry consciously to prepare for war in 1914 constituted a limitation on that initial advantage. His conclusions are drawn from published data, plus a few unpublished German sources.

The extent to which Beer brings the German dye industry into the realm of the familiar is illustrated by his remark that "the only reason all the dye companies continued to spend heavily on dye research was for prestige reasons very similar to those which impel the American auto industry to change models every year" (page 123). He emphasizes the role of capitalistic enterprise as a factor in the spectacular growth of the dye companies and notes that Carl Duisberg (later board chairman of I. G. Farbenindustrie) credits to his observations of the American trusts in 1903 some of the ideas which led to the formation of the German combine. The detailed history of the I. G. Farbenindustrie is not a part of this book, however.

Having reduced the story of the German dye industry from the mysterious to the familiar, Beer points out that the factors cited point to the inevitable emergence of the institutional research activities represented by that industry. But he also points out that the coincidences of time and circumstance revealed by an analysis of a specific example such as this are often of the greatest importance in the world as it is. The truth of this is quite evident in the fascinating case history that he has written.

ROBERT P. MULTHAUF
Smithsonian Institution

Family Planning, Sterility, and Population Growth. Ronald Freedman, Pascal K. Whelpton, and Arthur A. Campbell. McGraw-Hill, New York, 1959. xi + 515 pp. Illus. $9.50.

A quarter of a century ago, voluntary parenthood seemed inconsistent with population maintenance. Demographers forecast declining populations with reasonable surety, for birth rates had been moving downward for more than a century. Then birth rates increased in practically all social and economic groups except the lowest, where the decline continued. Moreover, the increases were generally greatest in the groups where the birth rates had been lowest. Voluntary parenthood was consistent not only with childlessness and disappearance of ethnic differences but with a familistic orientation of life that would sustain continuing increase of the population. The assessment of the future population of the nation became a topic of wide conjecture.

The studies made by P. K. Whelpton of the Scripps Foundation for Research in Population Problems had shown that the measurement of trends in fertility should be based on the life-time performance of cohorts of women rather than on the levels of general or age-specific birth rates in specific time periods. However, the past childbearing record of cohorts of women did not provide an empirical basis for estimating future childbearing. These future estimates required knowledge of the wishes and anticipations of families, and of the probable relationship between the numbers of children that were expected and the numbers that would be born. It is these new dimensions of population research that were the goals of the study reported in *Family Planning, Sterility, and Population Growth.*

The Survey Research Center of the University of Michigan and the Scripps Foundation for Research in Population Problems cooperated in this study of family planning and fertility. The 2713 white, married women who were interviewed represented a probability sample of the national population of some 17 million white wives aged 18 to 39 in 1955. The trained interviewers of the Survey Research Center met with unexpected frankness and cooperation in the responses to queries concerning attitudes toward, and practices of, family limitation. Interviews were secured

with 91 percent of the women in the sample and less than ½ percent of those interviewed were unwilling to answer questions about contraception.

Summary that does not risk overgeneralization is difficult, for the questionnaire was elaborate and the classifications were intricate. There are analyses of sterility and fecundity, the use of contraceptives, and attitudes toward family limitation, methods of limitation, and expected family size; each of these categories is analyzed in relation to the others and to the actual and the desired numbers of children. In addition, all variables are related to such factors as religion, education, income, occupational status, the work of wives, and community background, and again they are considered separately and in relation to each other. Throughout the findings are striking, and they are consistent.

The ghost of biological interpretations of declining fertility is banished by the results of this study. There were no evidences of consistent differences in fecundity (the ability to bear children) between women of the various social and economic strata. The influence of impairments on fertility (actual childbearing) was limited by the fact that couples desired only a few children anyway. However, there are surprising findings in this report. Nine percent of all the women interviewed had been sterilized, many of them for contraceptive purposes. One in four of the wives who had ever been pregnant had had at least one fetal death. And approximately 13 percent of all completed pregnancies had been terminated with a fetal death rather than a live birth.

The fundamental finding of this study of a group of white, married women who constituted a probability sample of the national population was that most couples had a fairly specific idea of how many children they wanted, used contraceptives to space their children and to prevent conception when they had the desired number, and were reasonably successful in limiting the number of children if not always in precise spacing of the children. There were differences among subgroups in the dynamics of family formation, in attitudes toward and use of contraceptives, and in size of the completed family. Religion and educational level were more closely related to fertility variables than were income, occupational status, or community background, but a majority of the couples in all groups used some control method, and the predominant family in all groups was small. There was nationwide convergence toward the two-, three-, or four-child family as the ideal, the expected, and the fact.

Forecasts of future births utilized the past experience of cohorts of women, the marriage rates and the birth rates of ever-married women in the various cohorts, and the expectations expressed by wives in the study about the size of their completed family. In specific terms:

"The medium fertility projections for ever-married women assume a rise in family size to about 3 births per woman, with a timing pattern similar to that being developed by cohorts of the 1930s. The low series is based on a return to the small families (averaging about 2.5 births) of the cohorts of 1906-15 and a partial return to their older ages at marriage and childbearing. The high series allows for births per ever-married woman to rise to 3.3 (the maximum expectation of the wives interviewed) and for some continuation of the recent tendency to marry and have babies at younger ages" (page 372).

The three series of estimates of births were utilized in combination with conservative assumptions of future declines in mortality and continued net immigration in preparing three series of projections about future populations. The population used as a base was 171 million for the year 1955. The populations as of 1980 were 215 million for the low projection, 239 million for the medium projection, and 262 million for the high projection. The medium projection is the most interesting model, for it assumes a continuation of the marriage and birth-timing patterns of the women born in the 1930's with a completed family size of three births per ever-married woman. This is a small family pattern, and it yields an annual rate of population growth of only 1.3 percent a year in the last quarter of the century. Yet the continuation of the three-child family under the assumed conditions of early marriage and early childbearing within marriage would produce a population of 312 million by the year 2000 and a population of 600 million by the year 2500.

Let me add quickly that the authors stress again and again the implications of their study for continuing and wider research. The swift development of the two- to four-child family as a nationwide ideal and the almost nationwide achievement of a correspondence between the number of children desired and the actual number of children is incontrovertible evidence that values and behavior in family formation are not static. Repetitive surveys are needed to determine the patterns of correspondence between stated expectations and performance and to ascertain shifts in expectations as they occur. There is the further vast field of research on those factors that are associated with shifts in expectations as they relate to completed fertility, and with the timing of the actual births that lead to a rough equivalence of expectations and completed family size at given levels of expectations.

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Ten Steps into Space. Monograph No. 6, *Journal of the Franklin Institute*. Franklin Institute, Philadelphia, Pa., 1958. x + 202 pp. Illus. $4.

The ten *steps* of this small paperback book consist of ten lectures (by as many experts) given in a series at the Franklin Institute in the spring of 1958. Although intended for engineers and scientists, most of the material is not highly technical, and much of it is definitely on the popular level. The success of the lecture series led to the decision to attempt to reach a wider audience by publication in book form.

In the first lecture, Ley describes the story of space travel from the earliest speculations to the successes of today, and discusses vividly and simply many of the books, both scientific and science-fiction, that have appeared on the subject. Stehling's lecture, concerned with the fundamental components of rockets and their operation, is carefully developed in nontechnical terms. Richey compares solid, liquid, and nuclear fuels and discusses their characteristics in rather complete technical detail. Singer covers the various kinds of information, such as radiation and magnetic fields, that can be obtained from satellite flights, as well as the experimental techniques involved. Herget succeeds in describing celestial mechanics in a way that involves practically no mathemat-

ics, but he covers the work of Kepler and Newton and the principles of modern, man-made satellite flight. An interesting and detailed description of one particular satellite flight, that of Explorer I, is the subject of Heller's lecture. The most technical account in the book is Ehrcke's detailed mathematical analysis of satellite motion; King's discussion of the known data concerning the atmospheres of Venus and Mars is also technical. Simon gives an interesting description of biological physics, and includes a fascinating description of his own balloon flight to an altitude of approximately 90,000 feet. The series concludes with Levitt's stimulating discussion of the future space possibilities of fission, fusion, and solar energy (solar-sailing and photon-rockets are included); the strange relativistic effects that will occur at speeds approaching the speed of light are also considered.

The eminent scientists who delivered these lectures seem to have made a serious effort to get information across to the nonexpert. In almost all cases, they have succeeded well in accomplishing this challenging task. The level of most of the articles is about right for most of the readers of *Science*, and the book should merit their attention.

DONALD J. HUGHES

Department of Physics,
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A Treasury of Science. Harlow Shapley, Samuel Rapport, and Helen Wright, Eds. Harper, New York, ed. 4, 1958. xiii + 776 pp. Illus. $6.95.

Anthologies are difficult books to review because the reviewer must exercise a considerable amount of personal and subjective judgment. Either he likes the selections the compilers have included in their book or he doesn't. If the latter, he can always compile his own.

Some years ago I indicated that I liked the *Treasury of Science* [*Science* **104**, 430 (1946)]. Two editions later, I still find the book rewarding reading.

Arranged by large topics with numerous subdivisions, the book treats of science and the scientist, the physical world, the world of man, and the rocket and the atom. It is, of course, not possible to list all of the authors included in this scientific smorgasbord. Suffice it to suggest, therefore, that the interested reader will find tidbits from the writings of Sir J. Arthur Thomson, Patrick Geddes, Albert Einstein, Alan Gregg, and Ivan Pavlov. He will also find selections from Copernicus, Galileo, Newton, Bacon, Darwin, and Huxley.

Although most of the material appeared in the earlier editions, several new sections bring the book closer to today's newspaper headlines. Thus, there is a report on radio astronomy by A. C. B. Lovell, George Wald writes on the origin of life, and Warren Weaver reviews some of the thinking on the genetic dangers of fallout.

In summary, with this new edition *The Treasury* has attained the status of a classic and deserves to be read as well as quoted.

MORRIS C. LEIKIND

National Institute of Neurological Diseases and Blindness, National Institutes of Health

Air Pollution Control. W. L. Faith. Wiley, New York; Chapman and Hall, London, 1959. vii + 259 pp. Illus. $8.50.

This book is intended for those with technical training who are not specialists in the field of air pollution, as well as for intelligent laymen. It is not intended for those seeking a comprehensive treatise on air pollution, for it does not go into any particular phase of air pollution from a fundamental standpoint.

The introductory chapter describes the most important problems of air pollution somewhat superficially. It is surprising that, in the discussion of property damage, there is no mention of the damage to masonry and statuary which occurs in England.

The chapter on meteorology covers general factors that influence the stability of polluted atmospheres. A discussion of smoke problems is followed by a chapter dealing with other particulate materials such as dusts, fumes, and mists. Typical data showing the sources of dustfall and the concentrations encountered in various areas where air pollution exists are given. This material includes a section on sampling and the appraisal of stacks for dusts and fumes as well as brief descriptions of some instruments. In my opinion, sampling procedures should have been treated separately for all cases. Sampling and its concepts assume certain knowledge which is not readily available to the so-called intelligent layman.

The problem of controlling aerosol emissions is discussed in the section on dust, with a brief résumé of the various devices used, after the discussion of sampling. Again, the treatment is descriptive rather than fundamental.

The discussion of gases is similar to the discussion of the particulate problem, with particular emphasis on sulfur dioxide, hydrogen sulfide, and hydrogen fluoride. Again, sampling methods and control are covered by descriptive materials. Odor problems are discussed in a separate chapter.

Because of the author's personal interest in automobile exhaust, and because of the fact that the Los Angeles area has a serious problem in this respect, the discussion of automobile exhaust and its problems is rather complete. The treatment will be useful to those interested in assessing the present status of the Los Angeles problem.

Separate chapters on air pollution surveys and the legal aspects of air pollution complete the book.

An overall appraisal indicates that the author achieved at least one of his objectives. The book presents some concepts of air pollution to individuals with a technical background. I doubt that it will appeal to the intelligent laymen, as Faith presumed it would.

LESLIE SILVERMAN

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New Books

The ABC of Relativity. Revised edition edited by Felix Pirani. Allen & Unwin, London; Essential Books, Fair Lawn, N.J., 1959. 139 pp. $3.75.

Basic Data on Plasma Physics. Sanborn C. Brown. Technology Press and Wiley, New York; Chapman & Hall, London, 1959. 344 pp. $6.50.

Directory of Nuclear Reactors. vol. 1, *Power Reactors.* International Atomic Energy Agency, Vienna, Austria, 1959 (order from International Publications, 801 Third Ave., New York). 214 pp. Paper, $3.50.

The Exploration of Space. Arthur C. Clarke. Harper, New York, rev. ed., 1959. 214 pp. $4.50.

Exploring the Structure of Matter. Jean-Jacques Trillat. Translated by F. W. Kent. Interscience, New York, 1959. 214 pp. $4.85.

A Field Guide to Bird Songs of Eastern and Central North America. Houghton Mifflin, Boston, Mass., 1959. 2 records, $10. The records contain the songs and calls of more than 300 species of land and water birds.

Reports

Nitrogen Fixation in Lakes

Abstract. Incorporation of N^{15} into the fixed nitrogen fraction of natural lake waters has been studied for the purpose of estimating rates of primary nitrogen fixation. Experiments in Pymatuning Reservoir, Pennsylvania, in Lake Mendota, Wisconsin, and in two lakes in Alaska indicate that fixation occurs at measurable, sometimes high, rates.

Our understanding of the nature of soil fertility and the availablity of nitrogen under natural conditions expanded greatly upon the discovery and subsequent investigation of symbiotic nitrogen fixation in leguminous plants and nonsymbiotic fixation by soil microorganisms. Whether biological fixation of nitrogen *in situ* is a quantitatively important feature of the nitrogen metabolism also of bodies of water is not yet known, although marine and freshwater biologists have sometimes tacitly assumed that this is the case (*1*). The list of organisms known to be capable of fixing free nitrogen is long; included on it are species of blue-green algae (particularly of the genera *Nostoc* and *Anabaena*, but also of *Tolypothrix*, *Calothrix*, and others), common and often abundant constituents of freshwater plankton, as well as *Azotobacter* and photosynthetic bacteria, including some that have been isolated from the water and mud of Lake Mendota, Wisconsin (*2*). Organisms capable of fixing nitrogen are therefore known to occur in the aquatic environment; it remains only to show that they contribute significantly to the supply of fixed nitrogen there.

We have used uptake of the stable isotope N^{15} as a measure of nitrogen fixation in lake water. Our method employs preliminary removal of dissolved atmospheric nitrogen from water samples contained in special 1000-ml closed vessels by aeration with an 80:20 helium-oxygen mixture at a pressure of 0.8 atm. Sufficient N_2 containing 95 atom percent N^{15} is then added to bring the pressure within the vessel to approximately 1 atm, and the system is equilibrated by shaking. Samples are incubated either in the lake at the depth from which the water was originally collected or under specified laboratory conditions. Subsequent treatment is essentially the same as that applied by Rittenberg, Keston, Roseburg, and Schoenheimer (*3*) and by Burris, Eppling, Wahlin, and Wilson (*4*) in their studies (*5*).

Preliminary measurements were made on the following lakes in 1958 (samples were incubated in the lake): (i) Little Kitoi and Upper Jennifer lakes, Afognak Island (Kodiak region), Alaska; (ii) Pymatuning Reservoir (Sanctuary Lake), Pennsylvania; (iii) Lake Mendota, Wisconsin.

The amount of N^{15} incorporated into the fixed-nitrogen fraction was estimated in all of these instances by subtracting the measured atom percent N^{15} of laboratory air from that of the fixed-nitrogen fractions of the samples after incubation. It has become obvious that this method overestimates the excess of N^{15} for two reasons. (i) Air is not an adequate standard because it gives a value about 0.002 atom percent lower than N_2 from ammonium sulfate which has gone through the conversion procedure. The latter, therefore, provides a standard more comparable to the actual samples. (ii) Lake-water blanks sterilized and carried through the entire experimental procedure appear to be enriched by about 0.004 atom percent N^{15}, as compared with ammonium sulfate. We have, therefore, applied a correction of −0.006 atom percent to these data, not having used adequate blanks at the time the measurements were made. Rates computed in this way are obviously not particularly reliable but may be used as preliminary estimates. Seven measurements made in the Alaskan lakes during July and August yielded rates of fixation ranging from 0 to 0.0047 μg of nitrogen per liter per day. Fixation was not detectable in a single experimental series from Lake Mendota in late October. A single series from Pymatuning Reservoir on 4 October yielded rates of incorporation far too high to be canceled by the most conservative corrections for the blank, of the order of 0.8 μg of nitrogen per liter per day. This figure is based on duplicate samples, the results of which agreed within 1 percent. There is no reason to doubt that here nitrogen was fixed at a high rate. For all experiments in 1958, incubation periods ranged from 4 to 6 days.

In more recent experimental series from Pymatuning Reservoir (beginning 20 April 1959) use has been made of certain technical refinements: (i) reagent-grade ammonium sulfate (instead of laboratory air) was used as a primary standard for isotope ratio; (ii) lake-water blanks were carried through the entire procedure after initial autoclaving within the experimental vessels; and (iii) all experimental vessels were autoclaved prior to the introduction of the sample, sterile procedure being observed subsequently. Water for these experiments was collected at Pymatuning, transported to Pittsburgh, and treated as described above about 8 hours after collection; samples were incubated under constant illumination at 15°C (approximately the temperature of the water when it was collected) for varying lengths of time. The results are given in Fig. 1 as atom percent N^{15} (excess over ammonium sulfate and sterile lake-water blank) plotted against

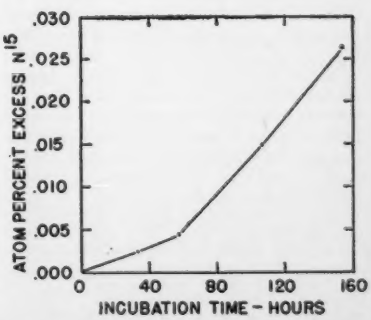

Fig. 1. Incorporation of N^{15} by surface water taken from Sanctuary Lake, Pymatuning Reservoir, Pennsylvania, on 20 Apr. 1959, incubated under constant illumination at 15°C.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

time of incubation. The curve appears to be characterized by two rates of fixation, one of about 0.021 μg of nitrogen per liter per day during the first 58 hours, the other of about 0.068 μg of nitrogen per liter per day during the rest of the experiment (*6*).

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JOHN NEESS
JOHN GOERING
Department of Zoology, University of Wisconsin, Madison

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2. E. S. Lindstrom *et al.*, *J. Bacteriol.* **61**, 481 (1951).
3. D. Rittenberg, A. S. Keston, F. Rosebury, R. Schoenheimer, *J. Biol. Chem.* **127**, 285, 291 (1939).
4. R. H. Burris, F. J. Eppling, H. B. Wahlin, P. W. Wilson, *Soil Sci. Soc. Am. Proc.* **7**, 258 (1942).
5. A detailed description of our entire procedure is in preparation.
6. We wish to express our appreciation to R. H. Burris of the department of biochemistry, University of Wisconsin, and Richard Abrams of the research laboratory, Montefiore Hospital, Pittsburgh, for the advice they have generously given and for the use of the mass spectrometers in their laboratories. Both spectrometers are Consolidated-Nier isotope ratio machines. This research was supported by the University of Kentucky Faculty Research Fund and by the National Institutes of Health. The Alaska Department of Fish and Game provided laboratory facilities at the Kitoi Bay Research Station on Afognak Island.

13 July 1959

Sensory Deprivation and Visual Speed: An Analysis

Abstract. Speeds of moving objects were markedly underestimated by human observers after prolonged patternless visual stimulation. Even greater underestimation followed exposure to a "noisy" visual field; on the other hand, exposure to a hyperstable field caused overestimation. The effects of external visual noise simulate those of deprivation; this finding suggests that similarly disordered but spontaneous neural discharge dominates the visual nervous system in deprivation.

Experiments in sensory deprivation have been made to explore the consequences of prolonged exposure to visual fields in which normal spatiotemporal variation is sharply reduced. Results of experiments performed at McGill University (*1*) suggest that the apparent speed of a moving line markedly changes as one consequence of long-term exposure to an illuminated but patternless visual field. After such deprivation, observers reported that a straight black line slowly rotating against a dimly lit screen looked S-shaped. This distortion was attributed to an induced "perceptual lag": the ends of the line lag behind the center.

In preliminary investigations we found no evidence for a perceived distortion of the line. Instead, the apparent speed of the entire line was clearly reduced. Consequently, in further investigations we have used an apparatus (Fig. 1) designed to measure and thus quantify changes in apparent speed (*2*). The observer was instructed to fixate a black dot 1 m distant at eye level. He then saw a black bar (Fig. 1, *A*) sweep, like the second hand of a clock, through 90 deg from a horizontal to a vertical position, at a rate of 60 deg/sec. At the vertical, the bar disappeared from the observer's sight behind a screen. His task was to judge when the now-hidden bar would reach a fixed marker (Fig. 1, *B*) 10 deg beyond. This judgment was based on the observer's estimate of the speed of the bar during its visible 90 deg of travel. When he judged that the hidden bar had traversed the 10 deg to reach the marker, he stopped the coupled time clock (Fig. 1) which gave a measure of the apparent speed of the bar. The average of the initial judgments made by practiced observers was very close to the actual travel time. Twenty trials per observer were made before and after each experimental exposure.

In a first test to evaluate our interpretation of the McGill results, seven observers were deprived of patterned vision for 8 hours under conditions similar to those of the McGill study (*3*). The observers, lying on cots, were subjected to a masking acoustic noise at the maximum tolerable level; they wore tubes over their arms and hands and translucent goggles over their eyes. The goggles provided only a homogeneously illuminated, nonpatterned field of vision. After deprivation, each of the seven observers judged the speed of the sweep to be less (by an average of 16 percent) than he had initially judged it to be. The observers showed no accompanying change in simple motor reaction time. Having demonstrated and measured this consequence of generalized deprivation, we proceeded to further analyses.

Each of 12 observers was instructed to fix his gaze on the center of a patternless but illuminated circular field (intensity 0.2 ml) subtending 43 visual degrees in an otherwise dark field (patternless exposure field). Although only visual input was controlled, a significant reduction in apparent speed was produced with only ½ hour of exposure (Table 1). This test demonstrates that control of extravisual stimulation is not essential for obtaining the change in apparent speed.

Table 1. Changes in apparent speed after ½ hour of exposure. Exposure fields: H, hyperstable; D, dark; P, patternless; N, noisy.

Exposure field	Change in speed (%)	Significance* of differences between conditions
H	+14.8	.05
D	− 4.8	N.S.†
P	−10.1	N.S.†
N	−19.6	

H vs. D: .01; H vs. P: .02; H vs. N: .001

* Significance levels derived from an analysis of variance. † Not significant.

Comparable experimental situations were then used to explore the effects of exposing the same observers to three other test fields devised on the basis of the following speculation. In the absence of normal stimulation coming from patterned fields, there is reason to suspect that the visual nervous system exhibits spontaneous and patternless activity (*4*). Dominance of the visual system for long periods by such intrinsic noise may result in reduction of

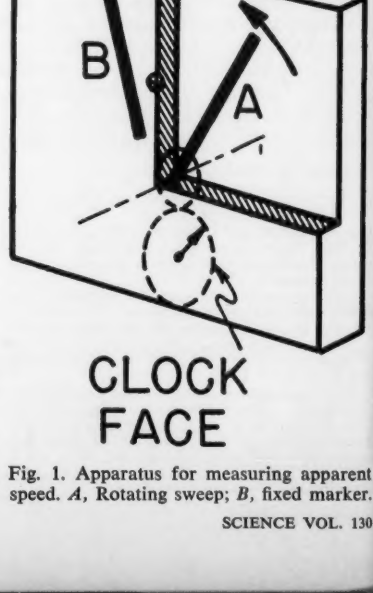

Fig. 1. Apparatus for measuring apparent speed. *A*, Rotating sweep; *B*, fixed marker.

apparent speed. According to this reasoning, even greater reduction should result from exposing observers to a barrage of randomized visual stimulation (extrinsic noise). An electronic device was used to produce a continually changing display of dots on the face of a 14-inch television tube. The resulting pattern may be called visual noise and defined as a changing pattern of dots devoid of redundancies of position or intensity (noisy exposure field). At the opposite extreme from visual noise there is stimulation with minimal temporal variation—a condition that can be produced by exposure to a fixed pattern, called here a hyperstable field because of the absence of even that amount of object-movement found in everyday scenes. To achieve comparability of exposure conditions we used a still photograph of the picture-tube display which showed the set of dots available at one instant (hyperstable exposure field). Such stimulation may suppress intrinsic noise to a degree greater than normal and hence cause an increase in apparent speed.

Finally, the observers were kept alert in total darkness for a comparable period (dark exposure field). Under the latter three test conditions, illumination level and field size (except for the dark exposure field), exposure time, and other controlled variables were equated with those of the first test. The order of presentation was varied for the 12 observers. The resulting changes in apparent speed are shown in Table 1. An analysis of variance showed that the differences among conditions were significant beyond the .001 level.

Thus, a method has been developed for quantifying one consequence of visual deprivation. Tests in which this method was used have yielded results consistent with the following propositions: (i) Simulation and enhancement of an aftereffect of visual deprivation through exposure to a noisy visual field implies that deprivation entails the randomization of sensory-neural activity rather than the diminution or absence of such activity. (ii) Production of an aftereffect opposite to that of deprivation, after exposure to a hyperstable field, implies that typical exposure fields have relevant noise characteristics somewhere between those of the noise used and those of the hyperstable field. (iii) The normal stability of speed perception depends upon continuous exposure to the typical environment.

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11 June 1959

Protection by Sulfur Compounds against the Air Pollutants Ozone and Nitrogen Dioxide

Abstract. Two distinct but related pathways of protection against the lethal effects of ozone and nitrogen dioxide are shown by (i) simultaneous inhalation of compounds that furnish −SH or −SS−, or both, and (ii) by injection of thiourea derivatives several days prior to exposure to these oxidant gases. The mechanism of (i) is believed similar to that proposed for the action of radiation-protective compounds; that of (ii) involves the development of a tolerance initiated by the thiourea against the oxidants.

Ozone (O_3) and nitrogen dioxide (NO_2) are potent respiratory irritants which may be injurious when inhaled (*1*, *2*), and evidence exists that the concentration of O_3 in urban air is damaging to plants (*3*). Nitrogen dioxide, in addition to acting as a pulmonary irritant, acts as a precursor of O_3 in oxidant smogs by photochemical dissociation (*4*).

In tests designed to determine the acute toxicologic effects of combinations of either known or suspected air pollutants, we found that certain sulfur compounds were effective in counteracting the toxic action of O_3 and NO_2. Partial protection by ascorbic acid against acute lethal effects of O_3 has been previously reported from our laboratories (*5*) as well as by Mittler (*6*), who also found slight protection by sodium thiosulfate. Mittler's conclusion that "compounds which protect against death by radiation . . . are not effective against ozone poisoning" is not supported by our work, however. Tests involved the inhalation exposure of mice to an approximate LC_{50} of either O_3 or NO_2 simultaneously with one or more sulfur compounds. In some instances the sulfur compounds were administered intraperitoneally prior to inhalation of the oxidant. Mortality resulting from a 4-hour exposure, as compared with the mortality from a control exposure to oxidant alone, reflected enhancement or suppression of O_3 or NO_2 toxicity as influenced by the sulfur compound. Methods of generation and analysis of O_3 and vapor concentrations of sulfur compounds have been described elsewhere (*5*, *7*). Gaseous sulfur compounds and NO_2 were similarly administered from cylinders in metered amounts and diluted to the desired concentration with purified air. The Saltzman method was used for NO_2 analysis (*8*).

The data in Table 1 represent selected results of a series of tests which show the maximal protection found for each sulfur compound. Comparison of mortalities in sulfur-treated versus control groups indicates the degree of protection afforded. Hydrogen sulfide (H_2S) gave significantly greater protection against oxidant exposure, particularly NO_2, than other sulfur compounds. On a molar basis H_2S protected in a ratio of 1/55 moles of NO_2, whereas benzenethiol, next in order of effectiveness, protected in a ratio of 1/5.4. Higher molar ratios of sulfur compounds were required for protection against O_3, however; for benzenethiol 1.5 mole/mole of O_3, and for H_2S, 2 mole/mole of O_3.

Table 1. Effect of sulfur compounds on the toxicity of nitrogen dioxide and ozone for mice. Mortality at 24 and 72 hours is indicated by deaths/number of mice tested.

Sulfur compound	Av. concn. (ppm)	Av. concn. of oxidant (ppm)		Mortality			
				S treated		Oxidant alone	
		NO_2	O_3	24 hr	72 hr	24 hr	72 hr
1-Hexanethiol	145	78		0/20	1/20	10/20	11/20
1-Hexanethiol	115		4.1	1/20	2/20	10/20	10/20
Methanethiol	65		4.8	2/15	2/15	9/15	9/15
Dimethyl disulfide	45	83		5/20	5/20	10/20	11/20
Dimethyl disulfide	21 mg/kg*	80		4/20	4/20	13/20	13/20
Dimethyl disulfide	21 mg/kg*		4.6	2/20	2/20	10/20	12/20
Hydrogen polysulfide	20 mg/kg*	105		8/25	8/25	16/25	18/25
Di-*tert*-butyl disulfide	24	84		4/15		9/15	
Benzenethiol	14	76		1/20	1/20	10/20	10/20
Benzenethiol	9		6.1	1/20	3/20	11/20	12/20
Hydrogen sulfide†	11		4.9	7/35	7/35	17/35	18/35
Hydrogen sulfide†	1.5	82		1/20	2/20	10/20	10/20
Thiophene	180	85		9/15		8/15	
Dimethyl sulfide	195		4.6	14/30		14/30	

* Administered by intraperitoneal injection. † An aged technical grade.

Certain —SS— compounds also gave protection against oxidant toxicity; both dimethyl disulfide and hydrogen polysulfide significantly protected intraperitoneally injected mice, and dimethyl disulfide and *tert*-butyl disulfide protected via inhalation. It is noted that purified H_2S provided less protection than that shown in Table 1 for a technical grade. This difference in protective ability is attributed on infrared evidence to the presence of —SS—, possibly hydrogen polysulfide, in the technical H_2S, and inasmuch as addition of —SS— to purified H_2S reinforced its protective ability.

The antagonism of oxidant toxicity by sulfur compounds is physiologic and not the result of chemical combination prior to inhalation to form less active compounds. Analyses of chamber atmosphere for oxidant gas showed essentially no change upon addition of sulfur compounds. Moreover, protection was conferred by the injected compounds. Histologic examination of pulmonary tissue showed degrees of tissue change that paralleled the protective effect. Pulmonary edema and cellular infiltration, characteristic responses of oxidant exposure, were markedly inhibited in the protected groups.

The mechanisms involved in the protection are, as yet, unknown. The functional unit appears to be —SH or —SS—, or both, but not —S—; dimethyl-sulfide and thiophene were ineffective. Significantly, —SH and —SS— are characteristic of compounds conferring protection against ionizing radiation (*9*). Brinkman and Lamberts (*10*) have called attention to the possible radiomimetic properties of O_3 by showing that O_3 and irradiation produced the same defect in oxygen consumption of the skin of the finger; also cysteamine was equally protective against the effects of both agents. Likewise, Fetner (*11*) has shown a similar capacity of O_3 and x-rays to produce chromosomal aberrations in *Vicia faba*. The action was presumably mediated through the OH and HO_2 radicals formed from the aqueous decomposition of O_3; the separate effects of O_3 plus irradiation were fully additive.

Single injections of MEG (2-mercaptoethylguanidine-HBr), highly protective against radiation at 200 mg/kg, gave modest protection against NO_2 (mortality: 8/20 S treated, versus 12/20 for NO_2 alone) and O_3 (13/20 versus 19/20). When given in a series of three injections (100 mg/kg on each of 3 days), however, MEG provided greater protection (2/20 versus 10/20 for NO_2 alone). Similarly, 0.04 mg/kg of BAL (2,3-dimercaptopropanol) provided some protection to mice exposed to NO_2 (6/22 versus 12/22 for NO_2 alone) but did not decrease O_3 toxicity (13/25 versus 12/25 for O_3 alone). Thus, there is similarity of action of protective compounds which favors the view that the mechanism of action of the oxidants O_3 and NO_2 may be in part similar to that of x-irradiation.

Another means of protecting against the lethal effects of NO_2 and O_3 was achieved by still other sulfur compounds, α-naphthylthiourea (ANTU) and phenylthiourea (PTU). Mice exposed to 5.8 ppm of O_3 the day following the last of 3 intraperitoneal injections of ANTU (10 mg/kg every other day) and rats which received 128 ppm of NO_2 18 days after administration of ANTU (8 mg/kg) showed marked tolerance to the oxidants. Comparative mortalities were: mice, 0/15 versus 12/15 for controls; rats, 1/6 versus 6/6 for controls. Similarly, PTU (8 mg/kg) given in four injections every other day and exposed to either O_3 or NO_2 3 days after the last injection produced good protection (4/10 versus 9/10 for O_3 alone, and 4/10 versus 8/10 for NO_2 alone). Although the mechanism presumably still involves reactive sulfur constituents, the pathway is obviously different from that mediated by —SH and —SS— compounds because the tolerance afforded by ANTU and PTU persists, a condition not met by the simple —SH and —SS— compounds. Also, unlike —SH and —SS—, simultaneous treatment with oxidant and ANTU (itself a potent producer of pulmonary edema) produces additive toxicity, instead of protection. It has been demonstrated that rats develop a marked tolerance to ANTU (*12*) and also to O_3 (*1*). The cross tolerance between ANTU and oxidant indicates that the basic mechanisms may be similar. Furthermore, it appears that the tolerance mechanism is related to the edema mechanism, and the latter to sulfur balance, inasmuch as —SH (cysteine) blocks the lethal effects of ANTU (*13*), whereas —SH or —SS—, or both, reduces oxidant toxicity.

It is felt that the antagonism to oxidants displayed by certain sulfur compounds is highly significant for the insight it provides concerning possible mechanisms for protection against air pollutants, and also toward elucidation of the hitherto unexplained toxic action of oxidants (*14*).

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16 July 1959

Uridine Isomer (5-Ribosyluracil) in Human Urine

Abstract. A substance isolated from human urine by anion exchange absorption and paper chromatography was found to correspond in its ultraviolet absorption spectrum and chromatographic mobilities with a uridine isomer (5-ribosyluracil) recently described as a component of yeast ribonucleic acid.

In 1957 Davis and Allen (*1*) reported the isolation from yeast ribonucleic acid of a new nucleotide ("the fifth nucleotide") and described its physical and chemical properties, notably a characteristic bathochromic shift in the ultraviolet absorption spectrum at alkaline *p*H. The corresponding nucleoside, prepared by the action of intestinal phosphatase, was subjected to hydrazinolysis, and the carbohydrate component was identified as D-ribose. Cohn (*2*) also obtained from yeast ribonucleic acid an "apparently modified uridylic acid" identical with the "fifth nucleotide" of Davis and Allen.

The structure of this new nucleotide proved to be of unusual interest. Recent investigation by Yu and Allen (*3*) revealed that the nitrogenous component is uracil and that the D-ribose, which has the furanose configuration, apparently is attached to the pyrimidine ring at the 5 position. Methylation studies by Scannell, Crestfield, and Allen (*4*) also indicated the structure to be 5-ribosyluracil. Further evidence for this formulation was obtained by Cohn (*5*) by means of periodate oxidation and nuclear magnetic resonance spectra. The C—C ribosyl linkage reported for the uridine isomer is unique thus far for components of nucleic acid, but C—C glycosyls occur in certain natural products (*6*).

A compound identical in spectral and chromatographic properties with this isomer of uridine was encountered in

Table 1. Spectral data for the urinary substance and for 5-ribosyluracil from yeast ribonucleic acid (from *3*).

*p*H	$\lambda_{max.}$ (mμ)	$\lambda_{min.}$ (mμ)	Ratios			
			250/260	280/260	290/260	300/260
			Yeast Ribonucleic Acid			
2	263	234	0.74	0.43	0.07	
12	286	245	0.64	2.09	2.16	1.22
			Urine			
2	263	233	0.75	0.43	0.08	
12	287	246	0.65	2.09	2.19	1.29

the course of an investigation of nucleosides occurring in urine in man (*7*). The urine of two adult males was studied. One was a normal subject; the other was gouty. Both abstained from consumption of tea and coffee for the period of study. The urine specimens were adjusted to *p*H 9 with ammonium hydroxide and were filtered. The filtrate was allowed to percolate through an amount of Dowex 2 (8×, 20-50 mesh) ion-exchange resin in acetate form equivalent to one-sixth of its volume. After washing-in with ammonium acetate buffer (*p*H 9) and water, the column was eluted with water. The aqueous eluate was collected in ⅛ column-volume fractions until the initial $E^{1cm}_{260m\mu}$ of 15.0 decreased to a value of 0.3. The combined fractions were evaporated to dryness under reduced pressure and at temperatures below 50°C. The residue was extracted with 60 percent aqueous ethanol. The extract brought to dryness *in vacuo* was dissolved in a minimum amount of water and applied to Whatman 3 MM filter-paper sheets for descending two-dimensional chromatography (*8*). A solvent system composed of *n*-butyl alcohol and 0.6*M* ammonium hydroxide (6:1) (*9*) was used in the long dimension of the sheet for 58 hours, and a system composed of *n*-butyl alcohol, formic acid, and water (77:11:12) (*10*) in the second direction for 17 hours. A spot which strongly absorbed ultraviolet light, located nearest the origin of the chromatogram, contained the uridine isomer. An extract of this spot gave the absorption spectrum shown in Fig. 1. The close correspondence of the spectral data with those reported for the uridine isomer derived from yeast ribonucleic acid by Yu and Allen (*3*) is indicated in Table 1.

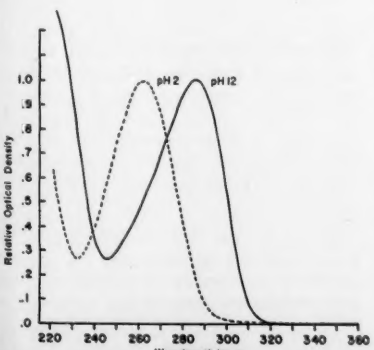

Fig. 1 Absorption spectra of the urinary uridine isomer.

A comparison of the chromatographic mobilities of the two compounds in four solvent systems was made (*11*). The relative mobility values of the spot extract coincided with those of authentic 5-ribosyluracil. Thus, in solvent system A [isobutyric acid, ammonia (0.5) (10:6)], the relative mobilities of the authentic sample and of the urinary product were 0.88 and 0.85, respectively (mobility of uridine = 1.0); in solvent system B [isopropanol, acetic acid, water (6:3:1)], 0.66 and 0.60; in solvent system C [tertiary amyl alcohol, water, formic acid (6:3:1)], 0.76 and 0.73; in solvent system D [butanol, water (86:14)], 0.53 and 0.48.

With three solvents (A, B, and C) the urinary product appeared homogeneous. The fourth solvent (D), however, revealed a small residual spot at its origin, indicating some impurity. We therefore used solvent D for further purification of a larger sample by band chromatography, obtaining a microcrystalline product.

A rough estimate of the amounts of the uridine isomer excreted in 24 hours was obtained by applying the figure for $\varepsilon_{max} = 7.5 \times 10^3$ at *p*H 2 given by Yu and Allen (*3*) to the spot extracts. Values of 18 mg/24 hr for the urine of the normal subject and 41 mg/24 hr for the urine of the gouty subject were obtained. Further studies are in progress to determine whether these differences in the gouty and nongouty subjects are consistent. In any event, both figures are in excess of the quantities of free purine bases reported previously in human urine (*8*).

The possibility that the uridine isomer found in the urine is derived from the diet is not excluded, although foods rich in nucleic acids, as well as coffee and tea, were omitted by the two subjects investigated. An endogenous origin is considered more likely, however. This would imply that the new uridine isomer occurs in human tissue, and this is in accord with the reported presence of the isomer in dog pancreas (*12*). It may belong to the class of naturally occurring "additional" nitrogenous constituents of ribonucleic acid which thus far are known to include 5-methylcytosine, various methylated purines, and thymine (*13*).

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15 June 1959

Production of Large Amounts of Plant Tissue by Submerged Culture

Abstract. The growth rate of plant tissue cultures is substantially increased through the use of a large-volume carboy system. Aeration is considered to be the most important factor. With this system, yields of a pound or more of tissue can be obtained within 2 weeks.

The methods of plant tissue culture have suggested a way to put the metabolic systems of plants to work under controlled conditions. A prerequisite for the most efficient use of this idea would be the large-scale production under submerged conditions of the tissue or tissues involved. Although the growth of microorganisms under these conditions is now commonplace, and advances in this direction with animal cells and tissues have been made (*1*), no such work has been reported for plants.

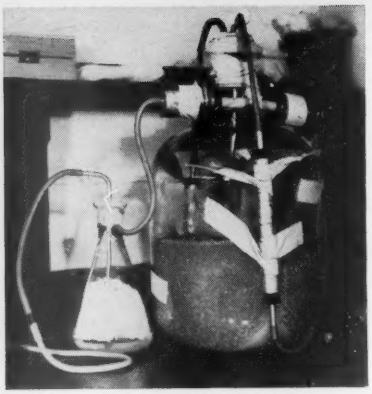

Fig. 1. The carboy culture apparatus. Aeration and agitation are accomplished by the introduction of compressed air (on the left) through a side-arm trap and then through two Seitz filters, which sterilize the air.

Since this approach constitutes part of the tissue-culture program in this laboratory, some of our results on the large-volume growth of plant tissue cultures are presented here.

The principal tissue used for large-volume culture was one obtained from Paul's Scarlet rose stems. This tissue was selected because of its rapid growth rate on solid media and the fact that it grows well in liquid culture. The medium used for carboy studies was made up of White's basal medium (*2*), 2, 4-dichlorophenoxyacetic acid (6 parts per million), yeast extract (0.1 percent), and malt extract (0.1 percent).

The inoculum for the carboy is prepared by taking the tissue culture from a test tube and placing it in liquid medium in a 300-ml erlenmeyer flask. This culture is then agitated on a New Brunswick gyrorotatory shaker. After 1 week's growth, the contents of one flask (the culture in 100 ml of medium) is transferred to a Fernbach flask containing 900 ml of medium. This flask is also aerated and agitated by shaking. After an additional week's growth, the Fernbach culture (1000 ml) is inoculated into a 20-liter carboy containing 9 liters of medium. This is the final stage of this particular scale-up. For purposes of aeration and agitation of the culture during growth, the carboy is fitted with stainless-steel tubing to receive compressed air, which is sterilized by passage through two Seitz filters (Fig. 1). In addition, appropriate connections are included for an air outlet, the addition of medium, and sampling. In all of these manipulations, aseptic procedures must be followed.

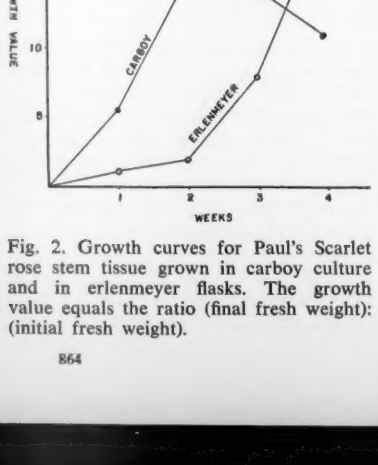

Fig. 2. Growth curves for Paul's Scarlet rose stem tissue grown in carboy culture and in erlenmeyer flasks. The growth value equals the ratio (final fresh weight): (initial fresh weight).

Samples of the carboy culture were made at weekly intervals and compared with results obtained from the same tissue grown on a New Brunswick gyrorotatory shaker in 300-ml erlenmeyer flasks containing 100 ml of culture. These results, shown in Fig. 2, indicate an accelerated rate of growth in the carboy for the first 2 weeks. Growth values (final wet wt./initial wet wt.) of 5.5 and 14.9 are attained by the tissue grown in the carboy system after 1 week and 2 weeks, respectively, as compared to growth values of 1.1 and 1.9 for the same periods with the shaker cultures.

The difference in growth rates between these two systems during the first week is due to the method of aeration. At the end of the first week of growth, 2 liters of medium were added to the carboy; the effect of this supplementation is an increase in rate of growth during the second week. When no further additions are made, the rate of growth drops off sharply, as shown by the growth values for the third and fourth weeks.

Other tissues also grow well in this carboy system of culture. The data available thus far for tissues from *Ilex* stem, *Lolium* endosperm (*3*), and *Ginkgo* pollen (*4*) indicate growth increases similar to the increase found with the Paul's Scarlet rose stem. The *Ginkgo* pollen tissue, for example, yielded 2 lb of cells after 4 weeks in carboy culture.

Other factors recognized as important in increasing the growth rate of plant tissue cultures are those well known to microbiologists working with large-volume cultures. Besides the necessity for an adequate nutrient medium, which itself may be improved in numerous ways, a number of physical factors are involved. In addition to the method and efficiency of aeration, which have already been stressed, the temperature of incubation and the means of agitation are important. More dependent on the tissue culture itself are such things as the age of the inoculum and the particular strain of tissue selected for growth. Moreover, the maintenance of a maximum growth rate rests on such things as timely addition of medium supplements, minimizing of foam production, and proper buffering of the hydrogen ion concentration.

From a practical standpoint, the carboy system of culturing plant tissues is a step in the direction of decreasing the lag phase of growth and increasing the ultimate yield. Our results emphasize the importance of timely nutritional supplements to the medium and of adequate aeration for the rapid growth of certain plant tissue cultures. The aeration factor receives major consideration in microbial "fermentations," but investigations with plant material have not been concerned with the growth of large amounts of material. In the roller-tube technique employed by Steward, Caplin, and Millar (*5*) and the variable-speed shaker technique used by Muir, Hildebrandt, and Riker (*6*), aeration has been studied, but the aim has not been the production of large yields (*7*). Another difference is that in both of these systems the agitation provides the aeration, whereas in the carboy system the aeration provides the agitation and at the same time furnishes a continuous flow of air.

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6 June 1959

Pipecolic Acid in Leaves of Strawberry Plant as Influenced by Treatments Affecting Growth

Abstract. Growth inhibition due to maleic hydrazide spray or to an unsatisfied chilling requirement caused young fully expanded leaves of the strawberry to accumulate pipecolic acid to a very striking degree. It is postulated that the accumulation resulted from blockage in normal metabolic conversion to other intermediary nitrogenous compounds.

Pipecolic acid is a naturally occurring cyclic imino acid that has been isolated from several plants and identified chromatographically in many others (*1, 2*).

Table 1. Nitrogenous fractions in young fully expanded strawberry leaves, in relation to treatments with maleic hydrazide (MH), 1957.

Treatment and date	Nitrogenous fractions: Total* (μg N / g fresh wt.)	Pipecolic acid: μg N / g fresh wt.	Pipecolic acid: % of total N
Variety: Sparkle			
None			
8/22	60.1	0.4	0.7
9/12	73.3	1.3	1.9
MH, 1000 ppm			
8/22	56.6	0.4	0.8
9/12	74.3	4.8	6.5
MH, 2000 ppm			
8/22	54.0	0.5	1.0
9/12	95.1	6.6	7.0
Variety: Catskill			
None			
8/25	78.9	1.0	1.4
9/12	81.3	1.1	0.4
MH, 1000 ppm			
8/25	65.3	1.4	2.3
9/12	94.6	3.2	3.4
MH, 2000 ppm			
8/25	73.1	1.6	2.2
9/12	78.4	9.5	9.7

* Alcohol-soluble ninhydrin–reacting substances.

Usually present in low concentration, it has been found to accumulate strikingly in the immature fruit and embryo of *Phaseolus vulgaris* (*2*). Working with that species, Grobbelaar and Steward (*3*) have found that lysine is converted to pipecolic acid, which in turn may be metabolized to α-amino adipic acid.

In the strawberry plant (*Fragaria chiloensis* var. *ananassa*) pipecolic acid is usually not found in very significant concentration among the alcohol-soluble ninhydrin-reacting nitrogenous compounds that are separated by two-directional paper chromatography. However, recent studies have indicated that this compound may accumulate dramatically in leaves of strawberry plants which are internally inhibited from active growth in spite of exposure to favorable growing conditions.

In the first of these studies, field-grown plants of the varieties Sparkle and Catskill were sprayed with aqueous solutions containing 1000 and 2000 parts of maleic hydrazide (MH) per million on 20 August and again on 4 September 1957. By 6 September, the growth-inhibiting effects of the MH sprays were visible, but there was no apparent injury to the leaf surface. Between 20 August and 15 September samples of young fully expanded leaves were taken at intervals of 2 to 3 days and preserved in 80-percent alcohol. The alcohol extracts were subsequently analyzed for amino acids by two-directional chromatography, with phenol and butanol-acetic acid used as the solvents. The pipecolic acid spots were identified by position and by their fluorescence in ultraviolet light. Quantitative estimation was accomplished by the procedure of Thompson and Morris (*4*). Table 1 shows the pipecolic acid concentrations (micrograms of N per gram fresh weight) in young leaves from untreated and MH-treated plants early and late in the experimental period. The rise in pipecolic acid due to MH was apparent in the Sparkle leaf samples by approximately 12 days after the first treatment, and accumulation continued progressively until the last sampling time.

In the second study, young Sparkle strawberry daughter plants were potted in late August and held outside until early November. They were then divided into two lots, one of which was held in the greenhouse at 65° to 75°F under 10-hour days, and the other subjected to chilling at 35° to 45°F continuously, also under short-day conditions. Approximately 2 months later the chilled plants were brought to the greenhouse. At that time both the chilled plants and those that had been held continuously at warm temperatures were separated into long (16-hour) day and short (12-hour) day lots. After a month, these four lots of plants were again divided, and half of each lot was sprayed with 100 parts of gibberellic acid (Gibrel) per million.

The unchilled plants grew more slowly and their leaves were smaller and darker green than those from chilled plants in all lots. In addition to the growth stimulus from chilling, there were additive stimulatory effects of long days and Gibrel. Thus, the unchilled, short-day plants that received no Gibrel grew least, and the chilled, long-day plants that received Gibrel grew most. Table 2 shows the effects of these treatments on pipecolic acid content, as micrograms per gram of dry weight, of the young fully expanded leaves sampled about 2 weeks and about 5 weeks after the chilled plants were brought to the greenhouse. At the first sampling the growth stimulus resulting from chilling was accompanied by a very great rise in ninhydrin-reacting nitrogenous compounds. As a result, although no consistent difference in the micrograms of N as pipecolic acid was apparent, that present amounted to 13.8 and 14.9 percent of the total soluble nitrogen accounted for in leaves of unchilled plants and only 3.6 and 4.9 percent of that found in leaves from chilled plants. Three weeks later, and about 2 weeks after Gibrel treatment, ninhydrin-reacting N had increased markedly in all the leaf samples from nonchilled plants and had decreased in the leaves from chilled plants. In addition, there was a striking increase in pipecolic acid N in all four leaf samples from unchilled plants, and this became the dominant form of ninhydrin-reacting N in those samples, rising to 39.6 percent of the total in the nonchilled plants that were under long days but did not receive Gibrel.

Table 2. Influence of chilling, day length, and gibberellic acid treatment on nitrogenous fractions in young, fully expanded leaves of the Sparkle strawberry, 1959.

Date and treatment	Nitrogenous fractions: Total* (μg N / g dry wt.)	Pipecolic acid: μg N / g dry wt.	Pipecolic acid: % of total N
Short day			
(1/30)			
Chilled	1283	46	3.6
Nonchilled	398	59	14.9
(2/19)			
Chilled	654	16	2.4
Nonchilled	769	146	18.9
(2/19)			
Chilled + Gibrel	733	14	1.9
Nonchilled + Gibrel	833	193	23.2
Long day			
(1/30)			
Chilled	1091	54	4.9
Nonchilled	279	39	13.8
(2/19)			
Chilled	485	11	2.4
Nonchilled	757	300	39.6
(2/19)			
Chilled + Gibrel	529	14	2.7
Nonchilled + Gibrel	570	96	16.8

* Alcohol-soluble ninhydrin–reacting substances.

Lysine was low in all samples and did not vary consistently as a result of treatments affecting growth. If α-amino adipic acid was present, it did not appear at the expected position on any of the two directional chromatograms in sufficient concentration to react with ninhydrin. It seems possible, therefore, that the increase in pipecolic acid associated with internal growth inhibition resulted from blockage in metabolic conversion to other compounds. (*5*).

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References and Notes

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5. We are grateful to J. F. Thompson and J. K. Pollard for advice and material assistance. This investigation was supported in part by research grant G5588 from the National Science Foundation.

30 April 1959

Meetings

Forthcoming Events

November

1–4. Society of Economic Geologists, Pittsburgh, Pa. (H. M. Bannerman, U.S. Geological Survey, Washington 25.)

2–4. American Clinical and Climatological Assoc., Hot Springs, Va. (F T. Billings, 420 Medical Arts Bldg., Nashville, Tenn.)

2–4. Atomic Industrial Forum, annual conf., Washington, D.C. (Atomic Industrial Forum, Inc., 260 Madison Ave., New York 16.)

2–4. Geochemical Soc., Pittsburgh, Pa. (K. B. Krauskopf, Geology Dept., Stanford Univ., Stanford, Calif.)

2–4. Geological Soc. of America, Pittsburgh, Pa. (H. R. Aldrich, 419 W. 117 St., New York 27.)

2–4. Mineralogical Soc. of America, Pittsburgh, Pa. (C. S. Hurlbut, Jr., 12 Geological Museum, Harvard Univ., Oxford St., Cambridge 38, Mass.)

2–4. National Assoc. of Geology Teachers, Pittsburgh, Pa. (F. Foote, Dept. of Geology, Williams College, Williamstown, Mass.)

2–4. Paleontological Soc., Pittsburgh, Pa. (H. B. Whittington, Museum of Comparative Zoology, Harvard Univ., Cambridge 38, Mass.)

2–5. Physical and Extractive Metallurgy, symp., Chicago, Ill. (Metallurgical Soc. of AIME, 29 W. 39 St., New York 18.)

2–6. American Inst. of Mining, Metallurgical, and Petroleum Engineers and Inst. of Metals, fall, Chicago, Ill. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

2–6. Collegium Internationale Allegalogicum, 4th symp., Rome, Italy. (A. Cerletti, Pharmacological Laboratories, Sandoz, Ltd., Basel, Switzerland.)

4–5. Diffraction, 17th annual conf., Pittsburgh, Pa. (P. K. Koh, Allegheny Ludlum Steel Corp., Research and Development Laboratories, Brackenridge, Pa.)

4–6. American Nuclear Soc., conf., Washington, D.C. (American Nuclear Soc., John Crerar Library, 86 E. Randolph St., Chicago 1, Ill.)

4–6. Antibiotics, 7th annual symp., Washington, D.C. (H. Welch, Div. of Antibiotics, Food and Drug Administration, Dept. of Health, Education, and Welfare, Washington 25.)

4–6. Design of Experiments in Army Research, 5th conf. (by invitation only), Fort Detrick, Frederick, Md. (F. G. Dressel, Office of Ordnance Research, Box CM, Duke Station, Durham, N.C.)

4–6. Eastern Analytical Symp., New York, N.Y. (P. Lublin, Publicity Chairman, Sylvania Research Laboratories, Bayside, N.Y.)

4–6. Industrial management Soc., Chicago, Ill. (R. J. Mayer, IMS, 330 S. Wells St., Chicago 6.)

4–6. National Automatic Control Conf., Dallas, Tex. (G. L. Turin, Hughes Research Laboratories, Culver City, Calif.)

4–6. Society of Rheology, 30th anniversary, Bethlehem, Pa. (J. T. Bergen, Armstrong Cork Co., Lancaster, Pa.)

4–6. Technical Assoc. of the Pulp and

Paper Industry, 13th alkaline pulping conf., Jacksonville, Fla. (TAPPI, 155 E. 44 St., New York 17.)

5–8. Group for the Advancement of Psychiatry, New York, N.Y. (American Psychiatric Assoc., 1700 18 St., NW, Washington 9.)

6. Gastroenterology Research Group, 9th semi-annual, Chicago, Ill. (E. Clinton Texter, Jr., Ward Memorial Bldg., Medical School, Northwestern Univ., 303 E. Chicago Ave., Chicago 11.)

8–13. International Rubber Conf., Washington, D.C. (B. S. Garvey, Jr., Pennsalt Chemical Corp., Industrial Chemicals Div., 813 Lancaster Pike, Wayne, Pa.)

9–11. American Petroleum Inst., 39th annual, Chicago, Ill. (API, 50 W. 50 St., New York 20.)

9–11. Association of Military Surgeons, 66th annual conv., Washington, D.C. (R. E. Bitner, AMS, Suite 718, 1726 Eye St., NW, Washington 6.)

9–11. Chemical Engineering, symp., Hamilton, Ontario, Canada. (Chemical Inst., 18 Rideau St., Ottawa 2, Ontario.)

9–11. Institute of Radio Engineers—Electronics Industries Assoc., fall, Syracuse, N.Y. (L. G. Cumming, IRE, 1 E. 79 St., New York 21.)

9–11. Instrumentation Conf., 4th, Atlanta, Ga. (W. B. Jones, Jr., School of Electrical Engineering, Georgia Inst. of Technology, Atlanta 13.)

9–12. Society of Exploration Geophysicists, 29th annual intern, Los Angeles, Calif. (B. Roberts, SEG, 1544 N. Highland Ave., Los Angeles 28.)

10–12. Electrical Techniques in Medicine and Biology, 12th annual conf., Philadelphia, Pa. (D. A. Holaday, College of Physicians and Surgeons, Columbia Univ., New York 32.)

10–15. Laboratory Measurement and Automation Techniques in Chemistry, intern. cong., Basel, Switzerland. (ILMAC, 61 Clarastrasse, Basel, Switzerland.)

11–12. Clinical Anticancer Drug Research, Washington, D.C. (B. H. Morrison, III, Cancer Chemotherapy National Service Center, National Cancer Inst., Bethesda 14, Md.)

11–13. Gerontological Soc., Detroit, Mich. (R. W. Kleemeier, Dept. of Psychology, Washington Univ., St. Louis 5.)

11–14. Society of Naval Architects and Marine Engineers, annual, New York, N.Y. (W. N. Landers, SNAME, 74 Trinity Pl., New York 6.)

12–13. Cardiology in Aviation, intern. symp., Brooks Air Force Base, Tex. (L. E. Lamb, Dept. of Internal Medicine, School of Aviation Medicine, Brooks Air Force Base.)

12–13. Operations Research Soc., natl., Pasadena, Calif. (D. A. Katcher, 4608 Morgan Drive, Chevy Chase 15, Md.)

12–13. Utilization of Atomic Energy, 2nd annual conf., College Station, Tex. (G. M. Krise, Radiation Biology Laboratory, Texas Engineering Experiment Station, College Station.)

12–18. International Odontological Session (with 64th Paris Dental Congress), Paris, France. (J. Charon, Secretary-General, 31, rue Tronchet, Paris 8°, France.)

15–18. Society of American Foresters, 59th, San Francisco, Calif. (Soc. of American Foresters, Mills Bldg., 17th and Pennsylvania Ave., NW, Washington 6.)

15–19. American Soc. of Agronomy, Cincinnati, Ohio. (L. G. Monthey, 2702 Monroe St., Madison 5, Wisc.)

15–20. Radiological Soc. of North America, conf., Chicago, Ill. (Radiological Soc. of North America, 815 Medical Arts Bldg., Fort Worth, Tex.)

16–18. Molecular Structure, 3rd conf., Houston, Tex. (Robert A. Welch Foundation, 2010 Bank of the Southwest Bldg., Houston 2.)

16–19. Magnetism and Magnetic Materials, 5th conf., Detroit, Mich. (D. M. Grimes, Dept. of Electrical Engineering, Univ. of Michigan, Ann Arbor.)

16–20. American Rocket Soc., annual meeting, Washington, D.C. (J. J. Harford, ARS, 500 Fifth Ave., New York 36.)

16–20. Automation Cong., 5th intern., New York, N.Y. (R. Rimbach, 845 Ridge Ave., Pittsburgh 12, Pa.)

16–21. Antarctic Symp., Buenos Aires, Argentina. (R. N. Panzarini, Instituto Antarctico, Argentino, Cerrito 148, Buenos Aires.)

16–21. Disposal of Radioactive Waste, conf., Monaco. (Intern. Atomic Energy Agency, 11–13 Kärntner Ring., Vienna 1, Austria.)

17–19. Building Research Inst. (NAS–NRC), fall conf., Washington, D.C. (J. H. Houtchens, Information Services, BRI, NAS–NRC, 1145 19 St., NW, Washington 25.)

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18. Association for Psychiatric Treatment of Offenders, New York, N.Y. (M. Schmideberg, New York Acad. of Sciences, 2 E. 63 St., New York 21.)

19–21. Inter-Society Cytology Council, annual, Detroit, Mich. (P. A. Younge, ISCC, 1101 Beacon St., Brookline 46, Mass.)

20–21. American Mathematical Soc., Winston-Salem, N.C. (J. W. Green, Univ. of California, Los Angeles 24.)

20–21. Nuclear Fusion, symp., Austin, Tex. (Texas Symp. on Nuclear Fusion, P.O. Box 8005, University Station, Austin, Tex.)

22–24. American Soc. of Hematology, 2nd annual, St. Louis, Mo. (J. W. Rebuck, Henry Ford Hospital, Detroit, Mich.)

22–29. Pan American Child Cong., 11th, Bogotá, Colombia. (Office of Intern. Conferences, Department of State, Washington 25.)

23–24. Solid-State Techniques in Modern Instrumentation, symp., Philadelphia, Pa. (G. L. Eberly, 12 S. 12 St., Philadelphia 7.)

23–25. Fluid Dynamics (APS), Ann Arbor, Mich. (R. J. Emrich, Dept. of Physics, Lehigh Univ., Bethlehem, Pa.)

23–26. Technical European Conf. on Standards Applicable to Water (by invitation only), Copenhagen, Denmark. (World Health Organization, Regional Committee for Europe, 8 Scherfigsvej, Copenhagen.)

23–3. Inter-African Soils Conf., 3rd, Daloba, Guinea. (Committee for Technical Cooperation in Africa South of the Sahara, Abbey House, 2–8 Victoria St., London, S.W.1, England.)

25. Association for the Advancement of Psychoanalysis, New York, N.Y. (New York Acad. of Medicine, 2 E. 103 St., New York, N.Y.)

26–27. Association for the Utilization of Atomic Energy in Ship-Building and Navigation, Hamburg, Germany, Gesellschaft für Kernenergieverwertung in Schiffbau m.b.H., Hamburg.)

26–28. Central Assoc. of Science and Mathematics Teachers, Chicago, Ill. (G. G. Mallinson, Western Michigan Univ., Kalamazoo.)

26–28. Ceylon Assoc. for the Advancement of Science, Colombo. (K. Arumugam and S. Wijesundera, General Secretaries, Univ. of Ceylon, Colombo 3.)

26–29. Legal and Administrative Problems of Peaceful Use of Nuclear Energy, intern. conf., Rio Piedras, Puerto Rico. (J. Mayda, Faculty of Law, Univ. of Puerto Rico, Rio Piedras.)

27–28. American Mathematical Soc., Detroit, Mich. (J. W. Green, Univ. of California, Los Angeles 24.)

27–28. American Physical Soc., Cleveland, Ohio. (K. K. Darrow, Columbia Univ., New York 27.)

27–28. American Soc. of Animal Production, Chicago, Ill. (H. H. Stonaker, Colorado State University, Fort Collins.)

(See issue of 18 September for comprehensive list)

New Products

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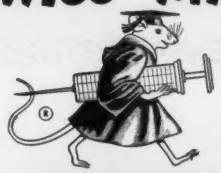

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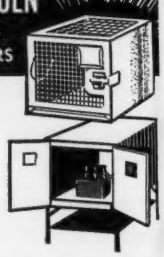

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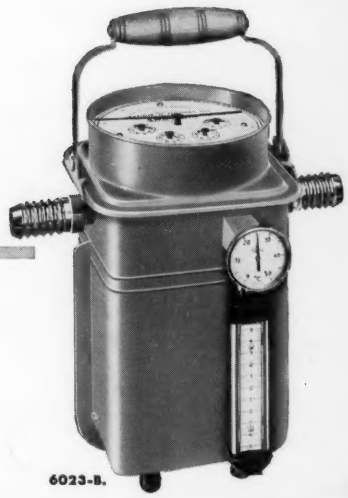

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Accuracy. Travel of large dial pointer is not perfectly uniform, so that reading may be in error by as much as ±150 ml at 1/3rd maximum rated capacity. If used for other than large volume tests in which such an error would be negligible, it is recommended that the error be determined by displacing known volume of air with water or by reference to measuring instrument of known accuracy. Maximum accuracy is obtained by use at steady flow rate approaching the maximum capacity.

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